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Converter test kit OPTIMUS for OPTIMUS 50/65/80 generators release 3.x with converters 4512 104 7231x

4512 104 91681

Level 1 Documentation

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Printed in Hamburg
Federal Republic of Germany

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Manual Order No. 4512 984 22723 Vers. 00

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SERVICE MANUAL - Unit

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Converter test kit OPTIMUS for OPTIMUS 50/65/80 gener-

ators release 3.x with converters 4512 104 7231x

Type no: 4512 104 91681

Manual Order No. 4512 984 22723
released: 05/2008

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1 INTRODUCTION

With this document it should be possible to determine which part of kV units of an Optimus generator is still operational and which part is defective and has to be replaced.

1.1 Scope of delivery

- 2 current transformers
  (ratio 1:1000, 20Ω resistors at the secondary coil give a ratio of 50A primary / 1V secondary)
- Test cable with resistor
- Test cable with diode
- This documentation

1.2 Tools

- Standard tools
- Extension boards C (96-pin)
- Dual trace oscilloscope with:
  - 2 probes for signals
  - 1 probe for external triggering
- Multimeter with diode test option
- 1 battery 1.5V D cell (R20) preferred
  C cell (R14) or AA cell (R6) possible

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2 GENERATOR CONDITION AFTER FAILURE EVENT

ENF1 and/or **ENF2** and/or **ENF3** tripped.

Mains fuses might have additionally tripped.

2.1 Special case

ENF3 tripped, possibly in combination with **ENF2** and **ENF1** and mains fuses:

Problem most likely caused by rotor control unit EY (high speed) or EYA (low speed).

Solutions for rotor control problems are not part of this document.

2.2 All other cases

The generator has to be kept in this condition to discover the cause of the problem.

A non-qualified person (e.g. hospital technician not familiar with Optimus) should not be asked to just turn the fuses back on to prevent further damage.

A qualified person like a Philips field engineer (trained on Optimus) must visit the site.

2.3 Prerequisites before checking the generator

CAUTION

Do not remove PCB kV-power from the IGBT transistors.
Electrostatic discharge and mobile phone waves can damage and destroy IGBTs when gate connections are open.

WARNING

The generator must be switched OFF and must be completely cut from mains (e.g. room mains switch or earth leakage current breaker).
All following checks must be made without mains power

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3 CHECK OF GENERATOR MAINS SUPPLY PARTS

- Measure DC voltage at auxiliary contacts 41-42 of ENK2.
  (Converter DC discharging contact, max voltage can be 750VDC.)

If 0V is measured:

– the contact is closed (and the converter DC is discharged within 1 minute)

or

– the contact is open and the converter DC is discharged and safe.

WARNING

In case one of the ENK2 main contacts is welded the converter DC discharge time is much longer as the discharging auxiliary contact ENK2 41-42 cannot be closed.
600VDC discharge time to < 60VDC normally **40 seconds**.
With open contact > **11 minutes** to be < 60VDC.

- Check if any main contact of contactor ENK2 is welded:
  Mechanical check: If snap-on auxiliary contacts or auxiliary contact block cannot be removed from the main contactor at least one contact is welded.

ENK2	phase 1	1 - 2	contactor ENK2	2422 132 06621
	phase 2	3 - 4	+ 3 aux. contacts NO	2422 135 04355
	phase 3	5 - 6	+ 1 aux. contact NC	2422 135 04023
		or		
		successor contactor		2422 132 07381
		+ succ. aux. cont. block		2422 135 04464
			+ succ. R/C circuit	2422 135 04661

- Record the conditions in the checklist (last pages).
- If contacts are found welded, replace contactor, its auxiliary contacts or contact block and the R/C circuit.

3.1 CONDITION(S) WHEN THE SERVICE COMES TO THE SITE

3.1.1 ENF2 tripped, possibly in combination with ENF1 and mains fuses

Problem might be caused by any of the:

– internal generator units (Optimus RAD + R/F)

or

– external units (Optimus RAD only) connected to breaker ENF2 :T1 :T2 :T3.

Solutions for such a case are not part of this document.

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3.1.2 ENF1 tripped, possibly in combination with mains fuses

Problem most likely caused by kV unit malfunction (kV-control, kV-power, converter(s), HV transformer) or external parts e.g. HV cable(s) or tube.

WARNING Make sure that the DC voltage in the converter is discharged.

- Open the cover of the frontal (and rear where present) converter.
- Measure DC at PCB kV-power EQ100 at E2 – C1 (at both converters, see layout drawings attached).
  The measured DC must be < 10VDC.

3.2 CHECK FOR OPEN SPRINGS AT DAMPING RESISTORS

EN	**:R1**	safety resistor 47Ω 100W	4512 100 45441
	:R2		
	:R3		

- Record the conditions in the checklist (last pages).
- Check for open springs at damping resistors.
  Springs might be open if all breakers are ON when the service comes to the site.
  In this case the generator must have been switched ON after all fuses and breakers were reactivated. Short-circuit in the converter or its mains rectifier/filter could have happened.
  Springs can be resoldered. If the springs have to be resoldered, use as little solder as possible.
- Check that the ceramic resistor bodies do not have cracks. In case of cracks the springs must be resoldered.

3.3 CHECK FOR CONTACTS THAT ARE WELDED AT BREAKERS AND CONTACTORS

- Switch OFF breakers ENF1 and ENF2.

ENF1	L1 – T1	automatic circuit-breaker ENF1	Optimus 50	2422 129 15514
	L2 – T2		or successor	2422 129 16291
	L3 – T3		Optimus 65/80	2422 129 15513
			or successor	2422 129 16292
ENF2	L1 – T1	automatic circuit-breaker ENF2	Optimus 50/65/80	2412 129 00341
	L2 – T2		or successor	2422 129 16288
	L3 – T3			
ENK1	phase 1 2 – 1	contactor ENK1	Optimus 50	2422 132 06625
	phase 2 4 – 3		or successor	2422 132 07382
	phase 3 6 – 5		+ R/C circuit	2422 135 04662
			Optimus 65/80	2422 132 06624
			or successor	2422 132 07383
			+ R/C circuit	2422 135 04662

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- Record the conditions of the breakers in the checklist (last pages).
- Check for contacts that are welded at breakers and contactors.
  If contacts are found welded, replace breaker(s) and/or contactor(s).
- Remove the converter mains lines (frontal and rear converter) from contactor ENK1 :1 :3 :5.

Measure with an ohmmeter each line against the others (of each converter).
There should be no short-circuit, the meter should display 2MΩ ±5% after at least 20 seconds (filter resistors).

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4 CONVERTER CHECKS (EQ FRONTAL AND E2Q REAR)

4.1 VISUAL CONVERTER CHECK

- Check the converter visually.
  The entire converter chassis must be replaced if cracks are visible at the white IGBT body (looking through the converter cage grid) or if the kV-power PCB Q100 is bent towards the cover plate.

4.2 MEASURING OF CONVERTER PARTS

Use an ohmmeter that has a diode test feature.

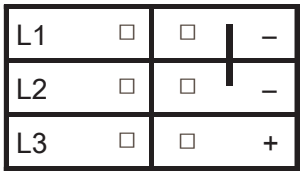
- Check the polarity of the meter (for ohm and diode testing):

Anode	of diode symbol on meter	=	positive voltage	>>	**PLUS**	(see measurement)
Cathode	of diode symbol on meter	=	negative voltage	>>	**MINUS**	(tables)

Ω	=	Normal ohm measurements
➜	=	Diode test option of meter

4.2.1 Rectifier check

- Open the right side of the converter(s) to get access to the mains rectifier.



Rectifier EQV5 layout

MINUS	PLUS →		PLUS	MINUS →	
L1 / L2 / L3 □	□ –	□ +	L1 / L2 / L3 □	□ –	□ +
	450mV ±10%	∞		∞	450mV ±10%

(Fig. 1)

- Record the conditions in the checklist (last pages).

4.2.2 IGBT check

Legend	Typical values when part is OK
	Typical values of defective parts If at least one test fails, the converter must be exchanged. Proceed with chapter 5.

The table below shows results of IGBT emitter - collector measurement.

Converter working OK and completely assembled.

Q100 kV-power PCB 4512 108 0862x / 0934x

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MINUS	PLUS	Ω	→	PLUS	MINUS	Ω	→
E1 E2,3,4	C1 C2,3,4	21.5 - 22kΩ	∞	E1 E2,3,4	C1 C2,3,4	16.5kΩ ±10%	300mV ±10%
Ex	Cx	0Ω	< 200mV	Ex	Cx	0Ω	< 200mV

The table below shows values of IGBT gate - emitter resistances.

Converter working OK and completely assembled.

Q100 kV-power PCB 4512 108 0862x / 0934x

MINUS	PLUS	Ω	PLUS	MINUS	Ω
G1 G2,3,4	E1 E2,3,4	3.8kΩ ±10%	G1 G2,3,4	E1 E2,3,4	4.2kΩ ±10%
Gx	Ex	0Ω	Gx	Ex	0Ω

- Record the conditions in the checklist (last pages).

4.2.3 Overvoltage diode check

Cathode = heat sink plate

MINUS	PLUS	→	PLUS	MINUS	→
Cathode V500 V501,2,3	Anode V500 V501,2,3	310mV ±10%	Cathode V500 V501,2,3	Anode V500 V501,2,3	∞
Cathode V5xx	Anode V5xx	0	Cathode V5xx	Anode V5xx	0

- Record the conditions in the check list (last pages).

4.2.4 Resistor check (PCB versions 4512 108 0862x / 0934x)

- Check 2 groups of 3 parallel resistors:

  R506 / 507 / 508
  and
  R509 / 510 / 511

  With 39Ω ±5% per group. Each resistor must have a resistance of 13Ω ±5%.
- Record the conditions in the checklist (last pages).

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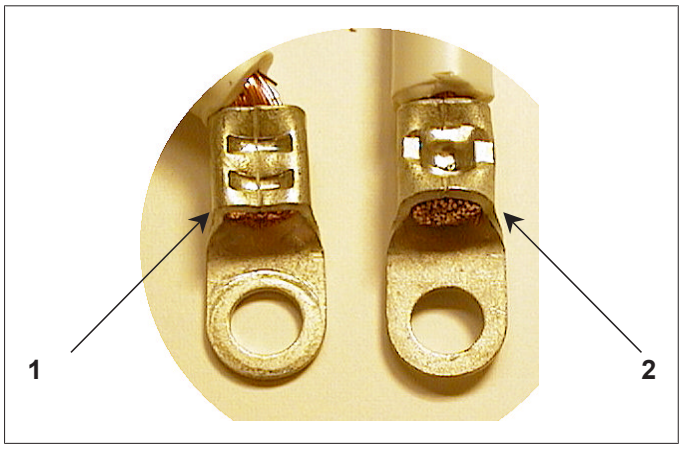
4.2.5 Power cable harness check

- Check internal converter power cable connections at resonance capacitors C3:2 and C13:2.
  If the connectors look like (**2**) no additional action is necessary.
  If one of the connectors looks like (**1**) and if signs of overheating are visible replace the converter.
- Record the conditions in the check list (last pages).



(Fig. 2)

4.2.6 Resonance capacitor check

- Remove primary lines from resonance capacitors C3:1 and C13:1 of frontal (and rear) converter.
- Check both capacitors for:
  – short-circuit
  – open connection

As it is not possible to measure the capacitance with an ohmmeter it is sufficient to see a variable resistance value for a certain time and finally a high resistance or open connection.

Once a high resistance or open connection is displayed reverse the measuring lines. If it comes again to an unstable resistance display with a high resistance or open connection display at the end, the capacitor should be OK.

If a capacitance measuring device is available it should display 8µF ±5% (apart from the meter tolerance).

If a capacitor is defective (short or open) and no other part of the converter is defective which requires a converter unit exchange, replace the capacitor (2019 321 00016).

- Record the conditions in the checklist (last pages).

NOTE

Leave the primary lines disconnected from the capacitors for further tests.

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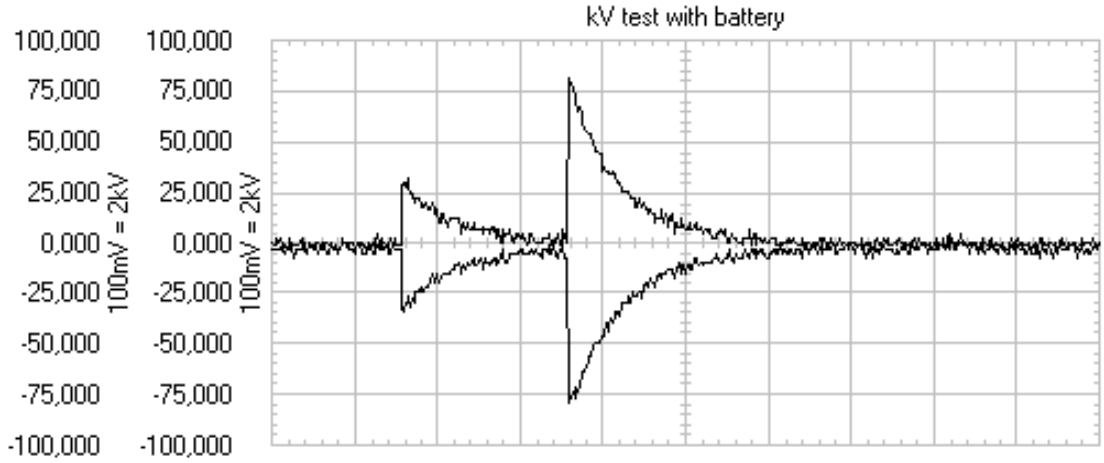
5 CHECK OF THE HIGH-VOLTAGE TRANSFORMER

- Remove PCB EZ130 kV-control.
- Insert an extender PCB at EZ130 X1 (or use the backpanel connections, which is less convenient).
- Establish oscilloscope connections:

channel 1	=	anode	EZ130 X1:C17	10 or 20mV/div
channel 2	=	cathode	EZ130 X1:C16	10 or 20mV/div
ground	=	EZ130 X1 :A17 :A16		
trigger	=	positive slope anode ch1 or negative slope cathode ch2 trigger level according to signal level		
time base	=	500ms/div or 1s/div		

Signal amplitudes might look different depending on the battery type, connection cables used and the ”contact force” at the battery.




```
Optimus 65/80:  +battery at GX1001 -battery at GX1002
Optimus 50:     +battery at GX1003 -battery at GX1002
first pulse:  battery connected
second pulse: battery removed
EZ130 removed, value measured at extension board X1
ch1 = anode   EZ130 X1:C17    upper signal, left scale
ch2 = cathode EZ130 X1:C16    lower signal, right scale
ground for both EZ130 X1:A17 :A16                    BATT1E.PCX
```

(Fig. 3)

- Measure

1. with high-voltage cables and tube connected.
2. with high-voltage cables only.
3. without high-voltage cables connected.

5.1 ANALYSIS

(**1**) and (**2**) have to look almost the same (symmetry and amplitude).
When (**1**) has a lower amplitude or a different kV behavior compared to (**2**) and (**3**) the tube might be defective.
(**3**) should have a steeper (faster) discharging ramp as the capacitance of the HV cable is missing (tank only 3nF, 20m cable typically 1.5nF) assuming amplitude and symmetry are the same.
When (**2**) and (**3**) look different (amplitude and symmetry) and if (**3**) is symmetric the HV cable(s) might be de-

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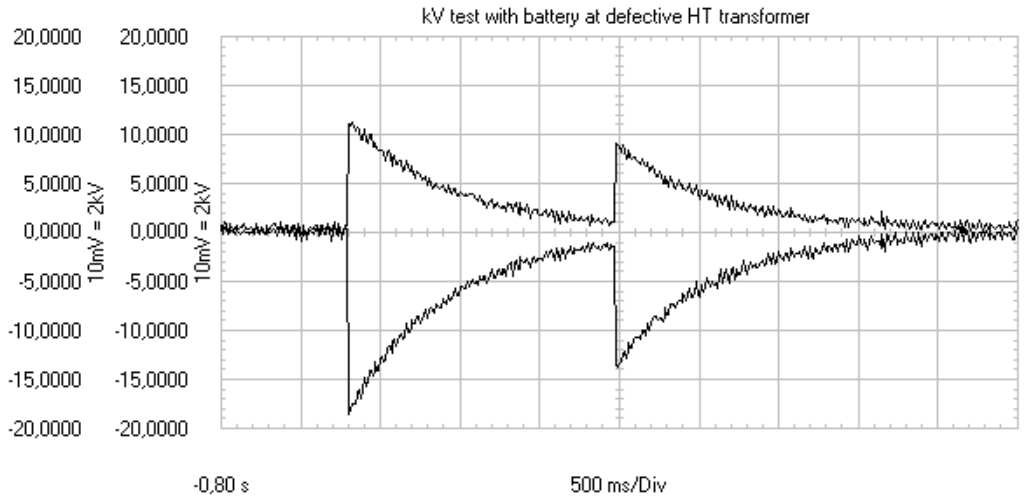
fective.
When (**3**) shows an asymmetric amplitude the HV tank must be replaced.

- Check against the following chart:




```
Asymmetric kV in case of
- shortcircuit at secondary coil    (anode side in this case)
- defective rectifier diode(s)      (anode side in this case)
Optimus 65/80:    + battery at GX1001    -battery at GX1002
Optimus 50:       + battery at GX1003    -battery at GX1002
1st pulse: battery connected, 2nd pulse: battery removed
EZ130 removed, value measured at extension board X1
ch1 = anode    EZ130 X1:C17    upper signal, left scale
ch2 = cathode  EZ130 X1:C16    lower signal, right scale
ground for both EZ130 X1:A17 :A16                          ASYM1_KV.PCX
```

(Fig. 4)

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6 VISUAL CHECK OF THE X-RAY TUBE

- If possible remove the collimator and the X-ray tube window assembly.
  Is there any visible damage?
- A cracked tube or the loss of its vacuum could be a reason to destroy the converter.
- Record the conditions in the check list (last pages).

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7 INTERIM RESULTS

At this point

– generator parts and units
– tube(s)
– HV cables

have been checked.

Something might have been exchanged or all tests came to an OK-result.

- Remove the extender PCB and reinsert kV-control EZ130.

WARNING

All followings checks must be made **with** mains power.
Check that the converter mains lines **still** have **no** connection to mains at ENK1 :1, :3, :5

- Switch ON all generator breakers and the mains supply.

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8 TUBE CHECK WITH ROTOR CONTROL PART 1

In case the tube was rotating during tripping of mains breakers the CPU remembers that the brake process has not been carried out (high-speed rotor control only).

About 40 seconds after switch-ON the tube brakes.

NOTE

If the anode disk is not rotating before switch-ON it sounds like an acceleration process.

- Switch ON the generator and perform an audible check at the tube housing during the generator start-up (for further explanations see chapter 10.)

As the mains lines are not connected to the converters, error messages 02HI and 02HJ come up (converter DC is 0V, therefore out of range).

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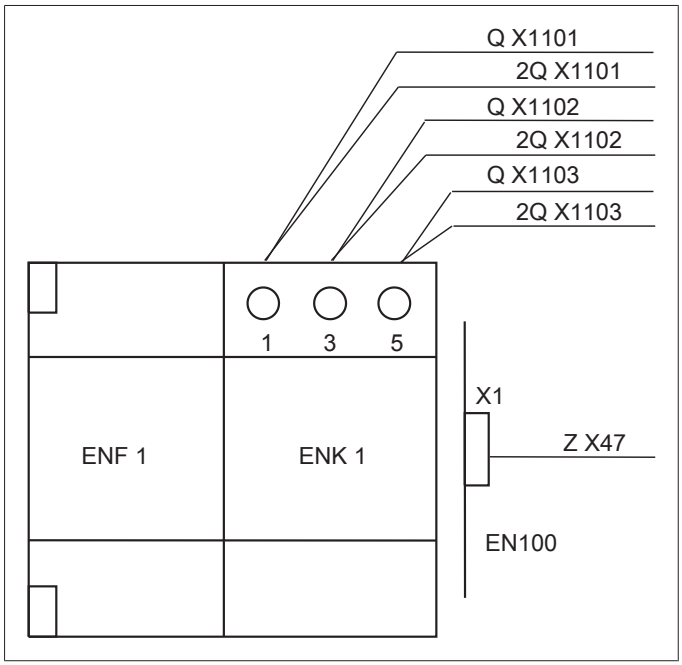
9 KV-DRIVER TEST

CAUTION

Before this driver test can be carried out the kV power unit(s) must be disconnected from the mains supply (leads of unit(s) EQ/E2Q to ENK1 :1, :3, :5)

This safety measure is also valid for the chopper test to guarantee that the measurements can be carried out without any risks involved.



(Fig. 5)

- Switch ON the generator.
  Ignore error codes 02HI and 02HJ now, the DC supply is off and these errors must come up.
- Check whether the gate voltage is about -14.2 V ±0.3V against emitter for every IGBT.
- Check the ±15 V supply for the IGBT drivers. Drivers 1 and 2 are supplied by chopper 1 while drivers 3 and 4 are supplied by chopper 2. The common zero point is the emitter.

Emitter	+15 V supply at heat sink	-15 V at resistor
E1, X101	A100 : 3	X102
E2, X201	A200 : 3	X202
E3, X301	A300 : 3	X302
E4, X401	A400 : 3	X402

The kV driver test is software-controlled via PC. Due to the missing PREP and exposure requests the signals **EN_X_C**/ and **CTRL_X_C**/ have to be set low–active at the backpanel at locations **X76** and **X74** (see drawing Z2-5.1/2).

CAUTION

Do not forget to remove these connections after the test. Otherwise kV start immediately with the PREP command in normal application mode.

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Test of control signal(s) and driver(s) behavior:

The range of the control signal is + 3.7 V ± 0.2 V for the ON condition and + 1.2 V ± 0.2 V for the OFF condition at the specified measuring point against generator ground (see schematic diagrams and PCB layout).
The range of the driver signal (gate against emitter) is - 14.2 V ± 0.3 V for the OFF condition and + 13.5 V ± 0.3 V for the ON condition.

- Select menu ”FU_kV/ Faultfind/ Functional Test/ Test Converter” at the service PC.
  The question [power supply mains - E disconnected ?:] comes up.
  Answer with ”yes” (type Return twice) and transmit with [F2].

If the test takes longer than 10 minutes it may happen that the test is denied by the kV control. This happens if the DC voltage = E–value is ≥ 5 V (the DC capacitors are slowly charged by the ±15 V of the drivers). Then short–circuit the DC at collector C1 and emitter E2.

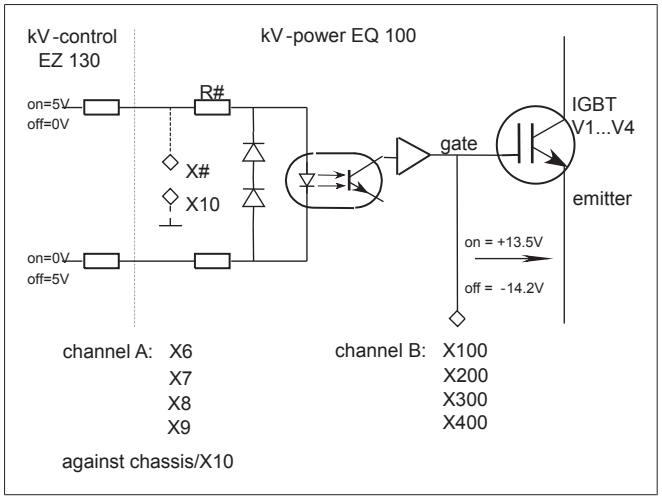
Do not establish a constant short–circuit to avoid problems after the test!

The test itself is short. The pulse time is 2.5 s long, but the PC screen displays **[completed]** after 5 s.
kV_control sends pulses for 5 s, but the hardware timer on the kV_control inhibits more pulses after 2.5 ms. Within this time the actual kV must be on the nominal value.

Test 1: Optical coupler / activation of the gate

Test 1: Input and output:

- Put a 2–beam oscilloscope to every measuring point of the control signals (channel A) and to every gate belonging to the inputs (channel B). Measuring points X6...X10 are present at the kV power unit.
- Trigger with the negative slope of channel A, take 10..50ms/div.



(Fig. 6)

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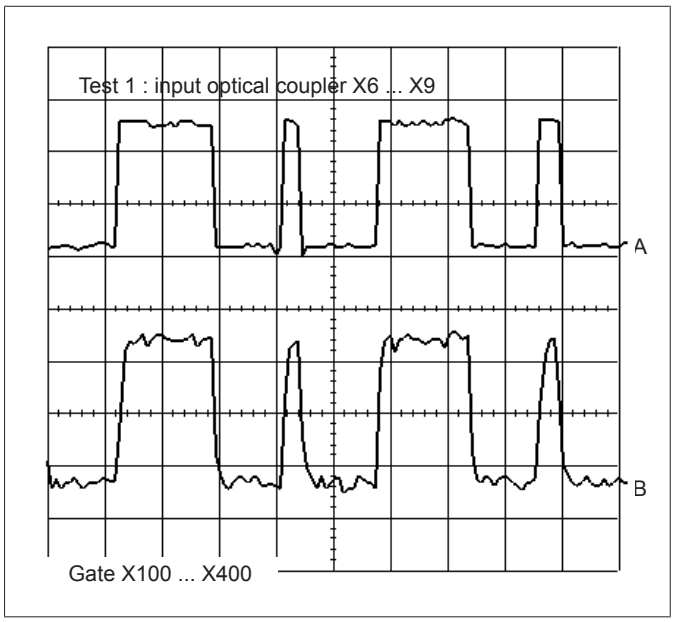
The wave form of the oscilloscope screen shot depends on the resolution of the oscilloscope.



(Fig. 7)

Test 2: Activation sequence of the gates: Inputs only

Test 2: inputs only:

- Check if the signal pattern of all 4 control signals look the same as on the diagram. Of course, only 2 channels can be seen at the same time, but the ”ONs” and ”OFFs” must be equal to the drawing.

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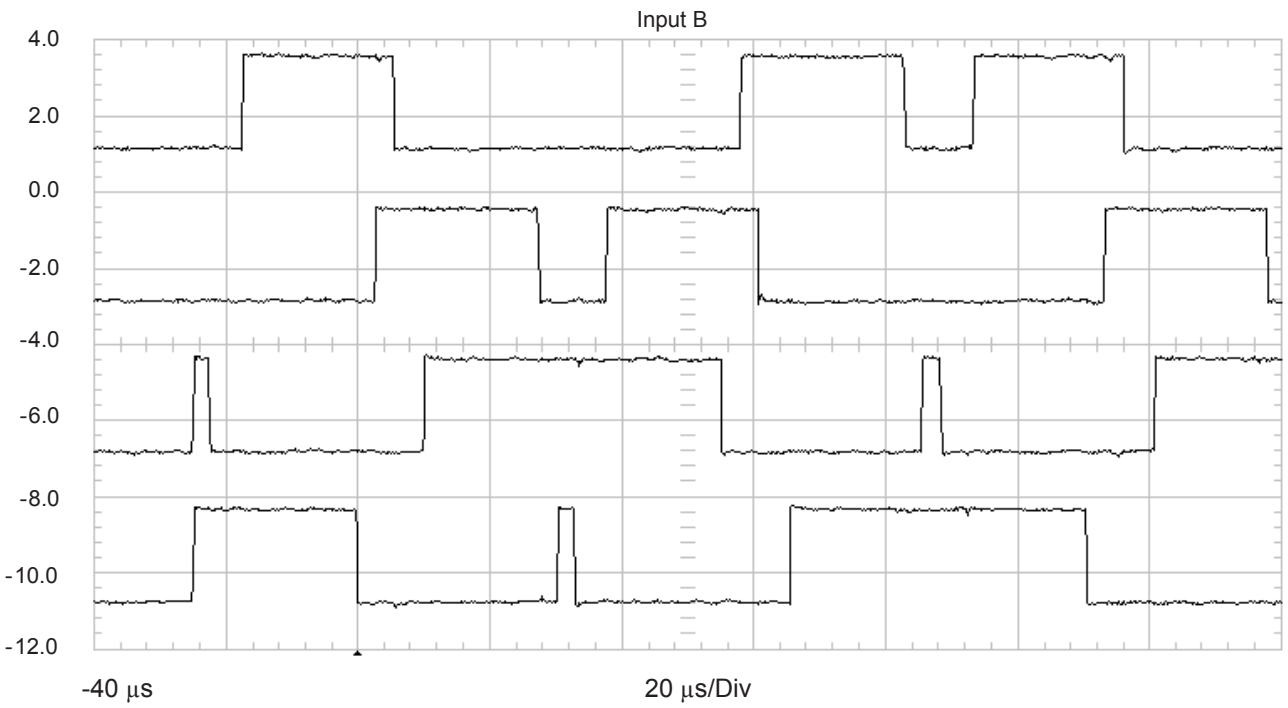

Signals from top to down, voltage scale for Ch1 only, active state high:

Ch 4 = Y100 x8 gate IGBT V3
Ch 3 = Y100 x7 gate IGBT V2
Ch 2 = Y100 x9 gate IGBT V4
Ch 1 = Y100 x6 gate IGBT V1

Average high level = +3.6V
Average high level = +1.2V

Whenever IGBT signals x6 (V1) + x9 (V4) or x7 (V2) + x8 (V3) are active high new energy is driven into the system. V1 + V2 or V3 + V4 must never be active high = on together.

(Fig. 8)

Test 3: Comparison of control signals of EQ with E2Q: only for w 65 kW

Test 3: only for 65/80/100kW with two kV power units:

- Compare control signals of both units.
  The signals at R25 of unit 1 must be absolutely equal to the signal at R25 at unit 2.
- If no problems are visible = all wave forms are as they should be:
- Switch off the generator with ENF1.
- Remove links EN_X_C/ and CTRL_X_C/ at the backpanel X76 and X74.
- Remove oscilloscope probes.
- Close the kV power part(s).
- Connect mains power lines at ENK1:1 :3 :5.
- Switch on ENF1 and the generator.

If the kV-driver test is successful prepare the generator for a next test:

WARNING

Switch OFF the generator .
Cut the generator completely from mains.

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- Lead the primary power cable(s) of QC13:1 (front and rear) through the current transformer(s) at each converter and reestablish the connection to the capacitor.

  Optimus 65/80 with 2 converters:
  Both current transformers must be inserted the same way.
  (Polarity, secondary transformer pins are marked with 1 and 2).

- Reestablish primary cable(s) at QC3:1 too.
- Reestablish all connections (mains cables of converter(s) at ENK1 :1 :3 :5.

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10 TUBE CHECK WITH ROTOR CONTROL PART 2

- Switch ON the generator.
  The system and the generator should be in ready condition.

Check of the tube vacuum:

- Push and hold PREP.
- Switch OFF the generator.
  The anode is in free run now.
- Listen at the tube housing:
  - If the anode speed is down within 2 ... 3 minutes the tube is defective (no vacuum) and must be replaced.
  - If a decrease of anode speed is not audible within several minutes the vacuum is still OK.
- Switch the generator back ON.
  - A generator with high-speed rotor control brakes the tube automatically (chapter 8).
  - At generators with low -speed rotor control wait for ready condition, push PREP once and let go of the PREP switch to brake the tube.

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11 TUBE AND HIGH-VOLTAGE CABLE TEST WITH HIGH VOLTAGE

Even if

– the battery test to check a short at the high-voltage cables (chapter 5),
– the visual tube check (chapter 6) and
– the audible tube check (chapters 8 + 10)

did not lead to defective parts at first sight, these might be discovered once high voltage is up again.

Therefore the following test procedure was created to switch exposures just for 1ms before any part of the generator might be overloaded from a defective tube or HV cable.

- Switch OFF the generator .
- Establish the **test cable with diode** at the backpanel service measuring points:

EZX74 (CTRL_X_C/	=	cathode of diode)	> open plug
and			
EZX77 (X_ACT_S/	=	anode of diode)	> green plug cover

- Establish just one side first (with the 4mm plug) of the test cable with resistor at the mAs short-circuit plug (either side, short-circuit plug remains in) of the measuring circuit EG100 (if access is not possible loosen screening cap of primary lines.)
- Establish oscilloscope connections:

channel 1	=	anode	EZ130 X4	AV_AN	20kV = 1V	0.5V/div
channel 2	=	cathode (also positive)	EZ130 X5	AV_CA	20kV = 1V	0.5V/div
ground	=	EZ130 X6/X32	GNDA			

trigger = signal CTRL_X_C/ at EZX74 **must** be used, negative slope, trigger level 2.5V
(if a third probe is not available use one channel for triggering with CTRL_X_C/ and check anode and cathode side individually)
time base = 200µs/div, trigger delay -1div

Explanation:

With these hardware modifications and exposure settings the exposure time is only 1ms.
The additional resistor simulates an emission current of 500mA which lets the mAs counter of mA-control terminate the exposure at 1ms (= 0.5mAs).

Under normal conditions the mAs counter is triggered by the signal X_ACT_S/. As this might be missing due to a problem in the system the additional diode drives, the kV start command CTRL_X_C/ also at X_ACT_S/ to trigger the mAs counter and ensures the short exposure. The oscilloscope must be triggered with CRTL_X_C/ for the same reason to get a display.

- Switch ON the generator.
- Set one RGDV for the following procedure or create a new RGDV just for the test (ignore other settings in data set A):

Enable handswitch at generator desk:	Yes
Syncmaster present (e.g. grid contact):	No
Exposure switch type:	Double Step
Installed radiographical controller:	none
Release circuit adaptation unit:	none
Installed tomo extension:	none

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- Start with **40kV**, **50mA**, **10ms** (= 0.5mAs). If the tube is not adapted set **40kV 0.5mAs**.
- Establish the **second side** of the **test cable with resistor** at backpanel plug
  EZX18 (Optimus 50)
  or
  EZX19 (OM 65/80) (backpanel layout page Z2-5.2).
  If EZX19 is used take 1WA X42 or 2WA X42 or 1WB X42 (see layout Z2-15.1).

NOTE

If the test cable with resistor is connected, mA-control EZ119 might display a FATAL error condition (LED on) after a certain time. Then remove the plug and warmstart the generator.
Do not put the plug back in before the generator is in ready condition. Then continue.

- Switch on exposure.
- Compare the measured result with the four possible cases of the table.

Case 1:
Both, anode and cathode side, have the same kV rising slope and value up to the point when the exposure terminates (which is almost the set kV).
If so, increase kV value in 10kV steps up to the programmed max kV tube limit or the max. value which is used for application and check results with the table cases 1, 2 and 3 accordingly
(settings 50mA + 10ms or 0.5mAs for a non-adapted tube **must remain**!).
If the result is not case 1 carry out case dependent *actions* given in the table below and switch a second exposure.

CAUTION

Case 4 must not be carried out with a value higher than 40kV.

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Exposures to be switched with 50mA 10ms or 0.5mAs		**Measuring results**		*Actions* + ►**analysis**	
		Anode EZ130 X4	**Cathode EZ130 X5**	**HV cable**	**Tube**
case 1	one exposure	50% of set kV	50% of set kV	► **OK**	► **OK**
				increase kV by 10kV	
case 2	1st exposure	0 ≠ **anode kV < cathode kV** ≠ 0 or 0 ≠ **anode kV > cathode kV** ≠ 0		*interchange anode and cathode HV cables (at both sides, tube and transformer)*	
	2nd exposure			no change of measured levels: ► tube defective measured levels change: ► HV cable(s) defective	
case 3	1st exposure	**set** kV or **0**kV	**0**kV or **set** kV	*interchange anode and cathode HV cables (at both sides, tube and transformer)*	
	2nd exposure	**0**kV or **set** kV	**set** kV or **0**kV	► HV cable at the **0**kV side defective	
case 4	1st exp. **40**kV	**0**kV	**0**kV	*remove anode HV cable from tube* **and** *HV transformer side*	
	!! this test with 40kV only, no higher kV !!				
	2nd exp. **40**kV	**40**kV or **20**kV	**0**kV or **20**kV	► tube defective	

- Compare measuring results with examples of oscilloscope charts on next page.
- **Remove test cables with resistor and diode!**

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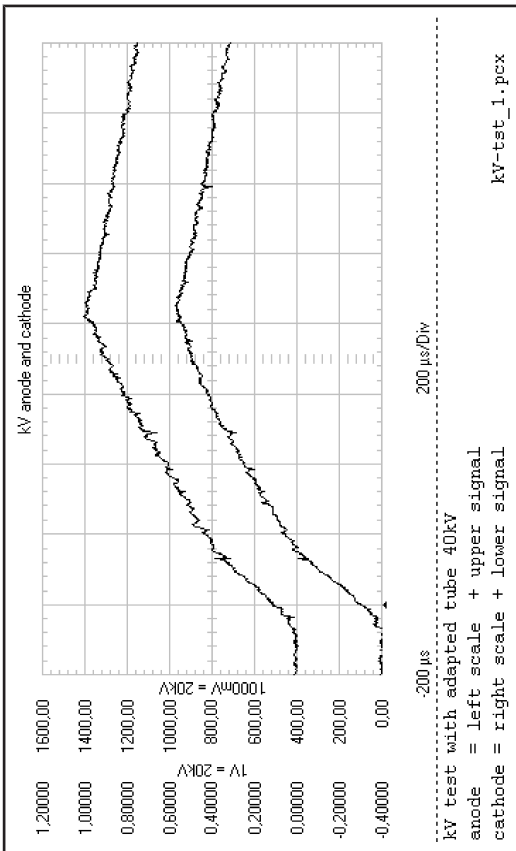
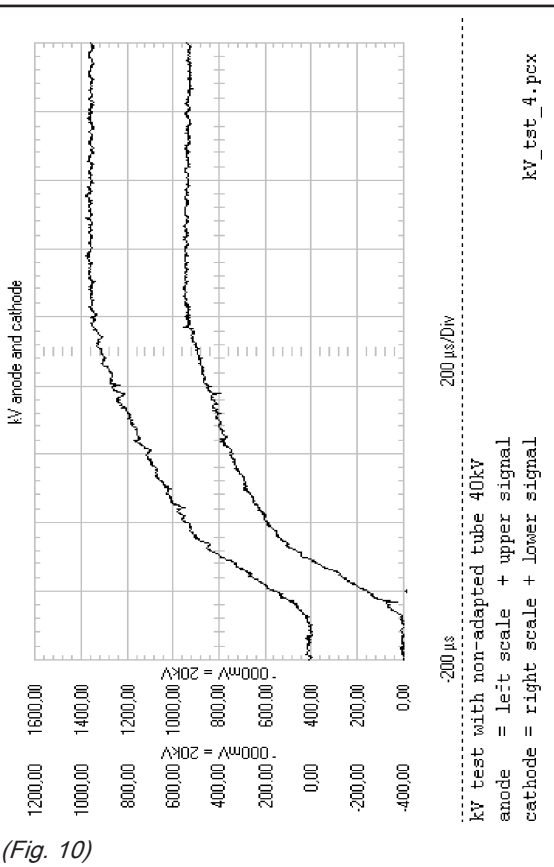


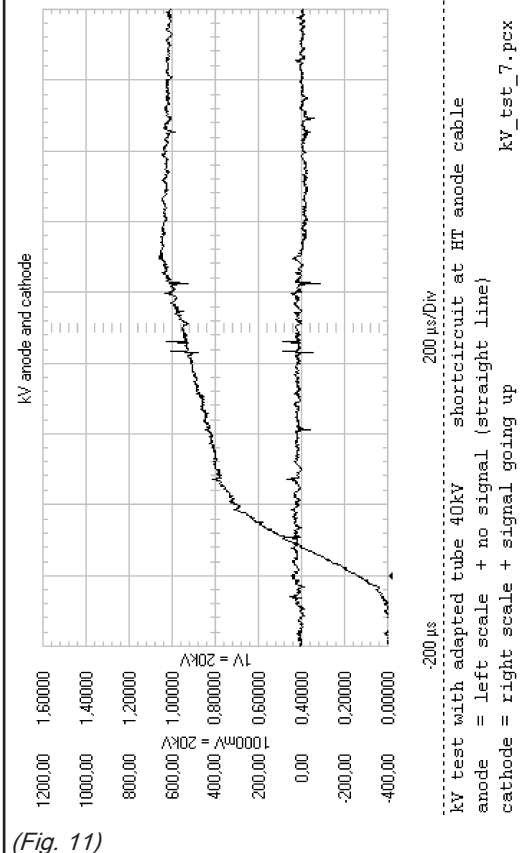
(Fig. 9)

▲adapted tube, tube and cable OK▲


kV anode and cathode
1200,00 1000,00 800,00 600,00 400,00 200,00 0,00 -200,00 -400,00
1600,00 1400,00 1200,00 1000,00 800,00 600,00 400,00 200,00 0,00
1000mV = 20kV
-200 µs
200 µs/Div
kV test with non-adapted tube 40kV
anode = left scale + upper signal
cathode = right scale + lower signal
kV_tst_4.pcx

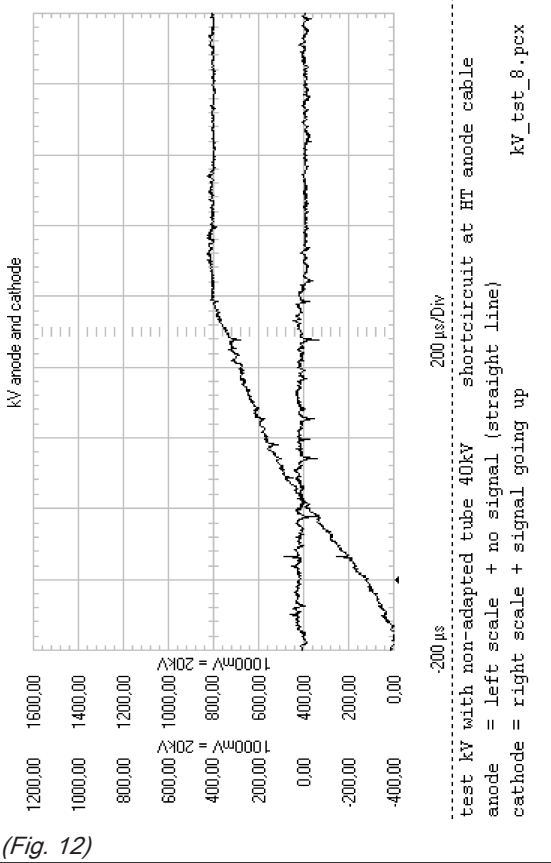
(Fig. 10)

▲non-adapted tube, tube and cable OK▲


kV anode and cathode
1200,00 1000,00 800,00 600,00 400,00 200,00 0,00 -200,00 -400,00
1,60000 1,40000 1,20000 1,00000 0,80000 0,60000 0,40000 0,20000 0,00000
1V = 20kV
1000mV = 20kV
-200 µs
200 µs/Div
kV test with adapted tube 40kV shortcircuit at HT anode cable
anode = left scale + no signal (straight line)
cathode = right scale + signal going up
kV_tst_7.pcx

(Fig. 11)

▲adapted tube, anode cable short-circuit▲


kV anode and cathode
1200,00 1000,00 800,00 600,00 400,00 200,00 0,00 -200,00 -400,00
1600,00 1400,00 1200,00 1000,00 800,00 600,00 400,00 200,00 0,00
1000mV = 20kV
-200 µs
200 µs/Div
test kV with non-adapted tube 40kV shortcircuit at HT anode cable
anode = left scale + no signal (straight line)
cathode = right scale + signal going up
kV_tst_8.pcx

(Fig. 12)

▲non-adapted tube, anode cable short-circuit▲

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12 MEASURING OF PRIMARY CURRENTS

- Switch OFF the generator and wait 1 minute for the converter DC to be discharged.
- Measure with the oscilloscope:

Signals:
Optimus **50**:
Establish one oscilloscope probe (signal and screen) at the current transformer secondary side.
Establish the second probe at EZ130 X3 AV_HT (actual value high voltage) and ground EZ130 X6.

Optimus **65/80**:
Establish both oscilloscope probes at the current transformers secondary side.
Check that signal and ground are at the same 1 + 2 transformer connections (polarity).

Trigger:
Use external trigger negative slope with low active CTRL_X_C/ signal at EX74 (backpanel).
If a third probe for an external trigger is not available:

Optimus **50**:
Use channel 2 (kV actual value AV_HT = 20kV/Volt) positive slope, trigger value according to probe divider.

Optimus **65/80**:
Set the trigger point level at channel 1 or 2 according to the expected amplitudes (see charts).

Time base:
According to charts. A trigger delay time (settings see charts) can be useful to see the start of the signals.

NOTE

Digital oscilloscopes sometimes display waveforms and spikes that do not exist or only parts of the signal are displayed.

The following charts were made with a 100MHz oscilloscope with different magnification factors (= time base).

- Switch the generator back ON.
- Set **40kV**, **50mA**, **10ms** (any focus). In case the tube is not adapted set **40kV**, **0.5mAs**.
- Compare waveforms with the charts on the following four pages.

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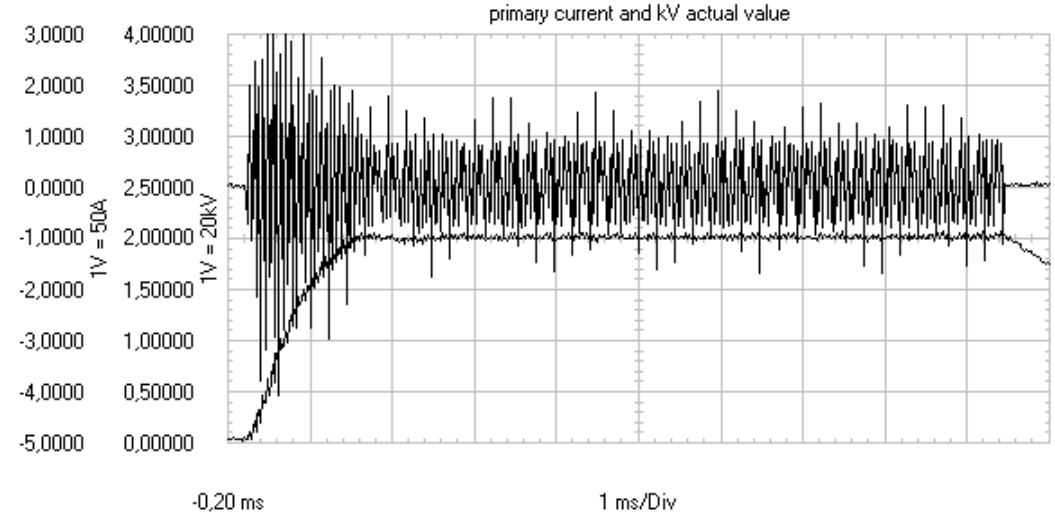
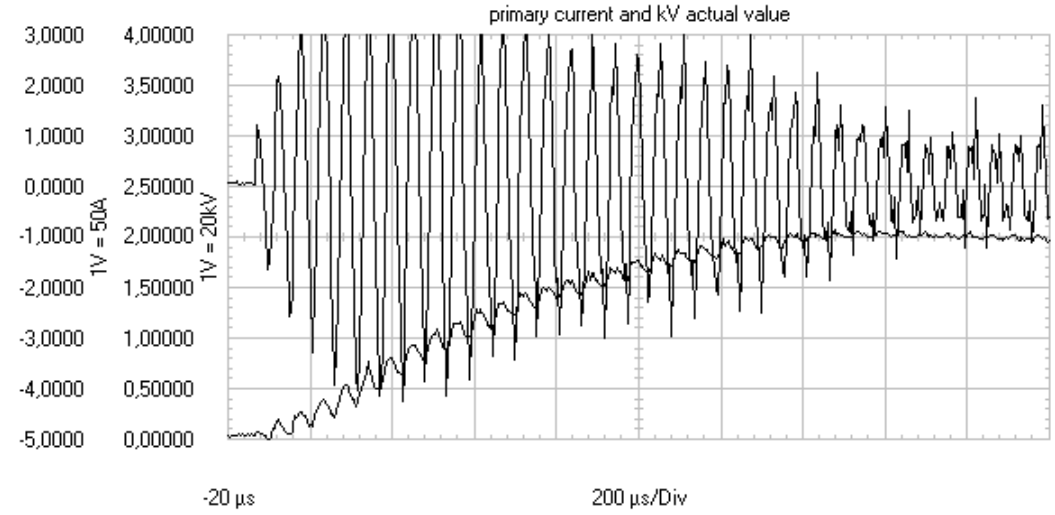
Optimus 50 tube adapted:




```
40kV 50mA 10ms, primary current and kV during the entire exposure
Optimus 50
ch1 (upper signal, left scale)  = EQ converter at primary line C13:1
ch2 (lower signal, right scale) = kV actual value AV_HT EZ130 X3
                                                              50_1.PCX
```

(Fig. 13)




```
40kV 50mA 10ms, primary current and kV during kV rise
Optimus 50
ch1 (upper signal, left scale)  = EQ converter at primary line C13:1
ch2 (lower signal, right scale) = kV actual value AV_HT EZ130 X3
                                                              50_2.PCX
```

(Fig. 14)

The primary current values must be within the range of the lower chart ±10%.

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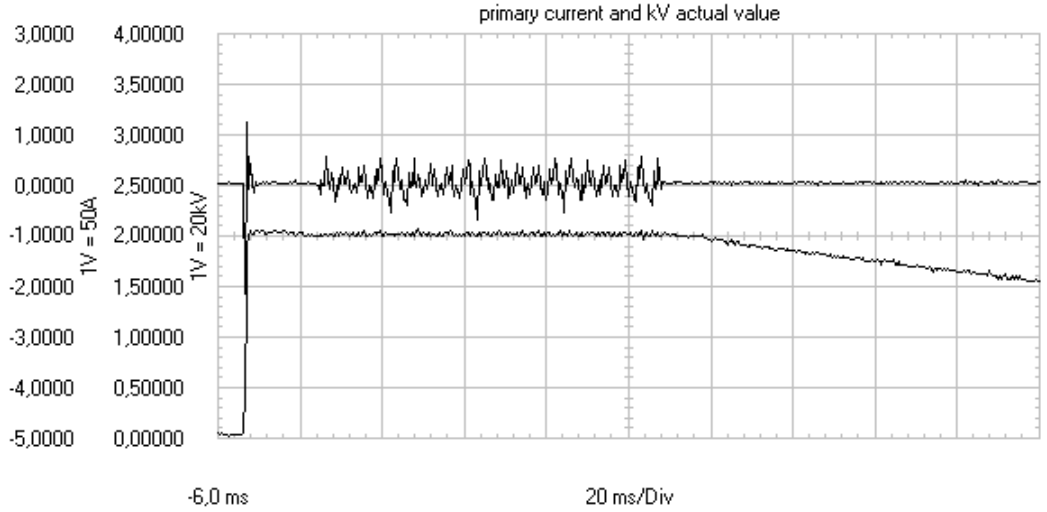
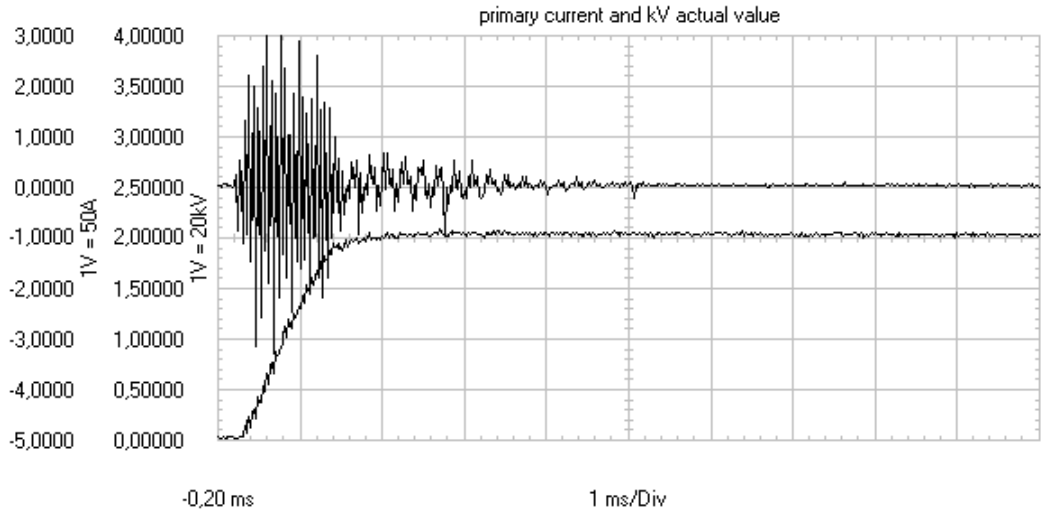
Optimus 50 tube not adapted:




```
40kV 0.50mAs, primary current and kV actual value
entire exposure with a non-adapted large focus
Optimus 50
ch1 (upper signal, left scale)  = EQ converter at primary line C13:1
ch2 (lower signal, right scale) = kV actual value AV_HT EZ130 X3
                                                              50_3.PCX
```

(Fig. 15)




```
40kV 0.50mAs, primary current and kV actual value
kV start of an exposure with a non-adapted large focus
Optimus 50
ch1 (upper signal, left scale)  = EQ converter at primary line C13:1
ch2 (lower signal, right scale) = kV actual value AV_HT EZ130 X3
                                                              50_4.PCX
```

(Fig. 16)

The primary current values must be within the range of the lower chart of page 26 ±10%.

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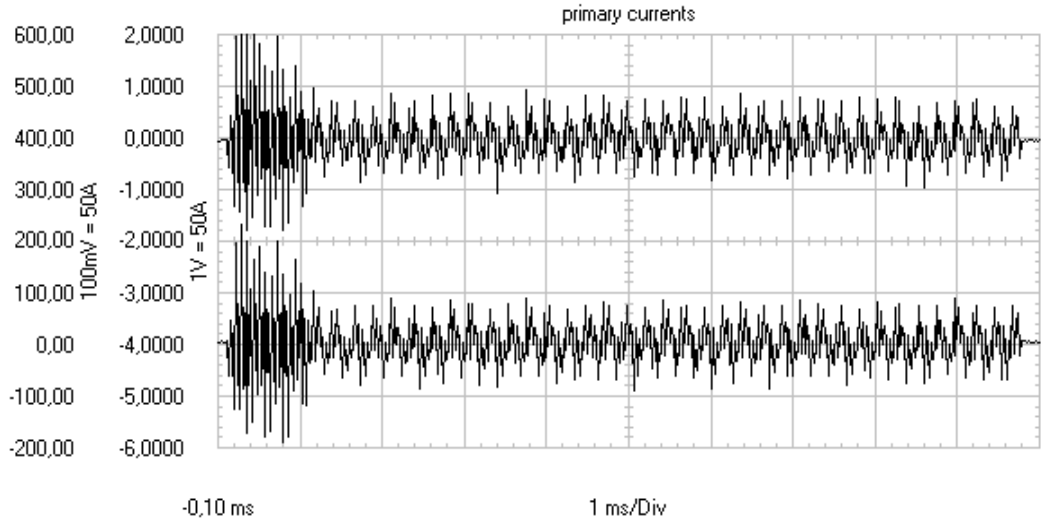
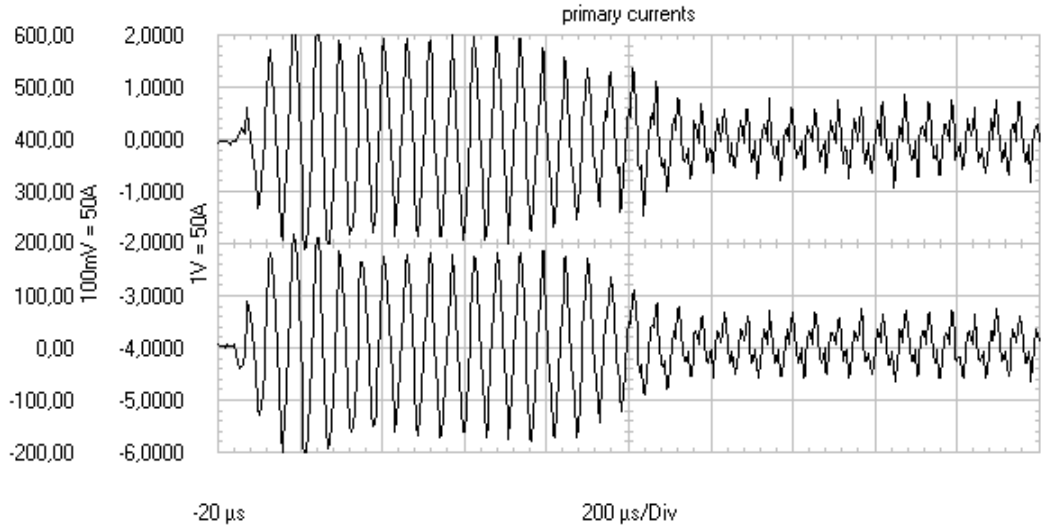
Optimus 65/80 tube adapted:



exposure 40kV 50mA 10ms, primary currents during the entire exposure
Optimus 65/80
ch1 (lower signal) = EQ (frontal converter) at primary line C13:1
ch2 (upper signal) = E2Q (rear converter) at primary line C13:1
(probes with different dividers used, left scale ch1, right scale ch2)
KV1E.PCX

(Fig. 17)



exposure 40kV 50mA 10ms, primary currents during kV rise
Optimus 65/80
ch1 (lower signal) = EQ (frontal converter) at primary line C13:1
ch2 (upper signal) = E2Q (rear converter) at primary line C13:1
(probes with different dividers used, left scale ch1, right scale ch2)
KV2E.PCX

(Fig. 18)

If waveforms are not symmetrical replace HV transformer.
The primary current values must be within the range of the lower chart ±10%.

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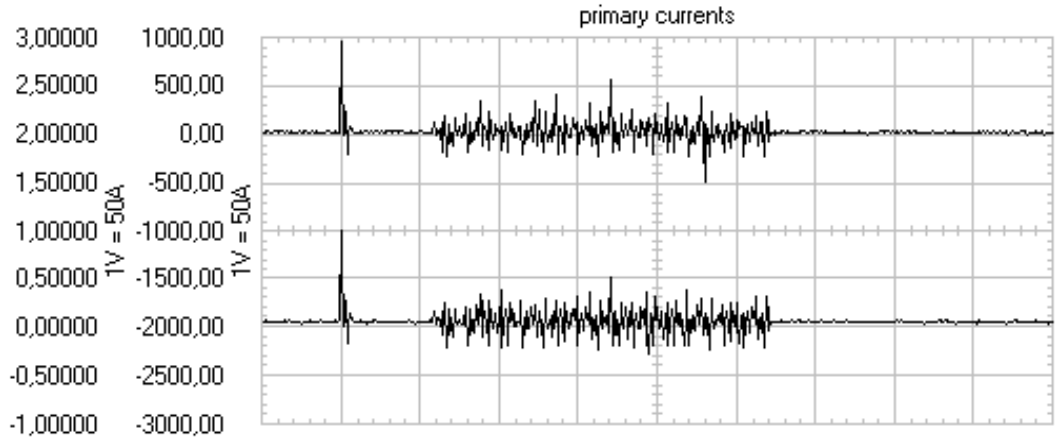
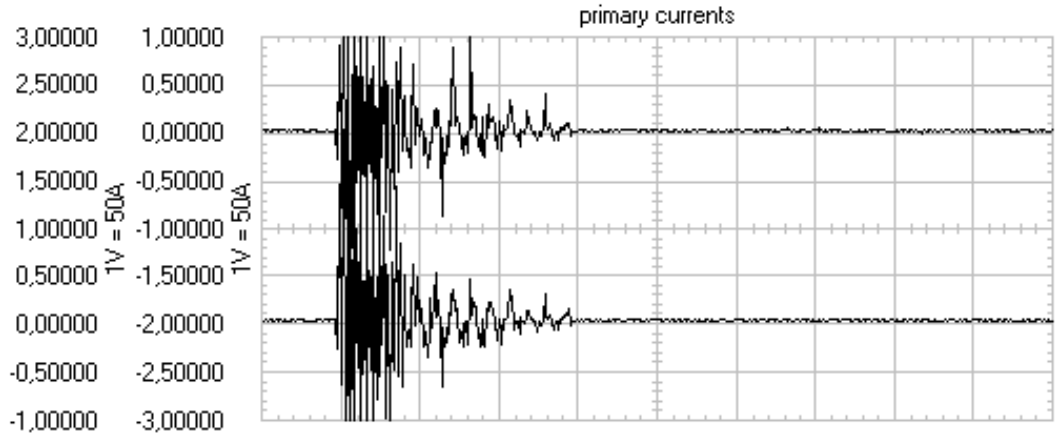
Optimus 65/80 tube not adapted:




```
exposure 40kV 0.5mAs  primary currents of a non-adapted large focus
('conditioning' mode when the desk displays "Test")
ch1 (lower signal) = EQ (frontal converter) at primary line C13:1
ch2 (upper signal) = E2Q (rear converter)   at primary line C13:1
                                                        LF_NONAD.PCX
```

(Fig. 19)




```
kV start of an
exposure 40kV 0.5mAs  primary currents of a non-adapted large focus
('conditioning' mode when the desk displays "Test")
ch1 (lower signal) = EQ (frontal converter) at primary line C13:1
ch2 (upper signal) = E2Q (rear converter)   at primary line C13:1
                                                        LF1NONAD.PCX
```

(Fig. 20)

If waveforms are not symmetrical replace HV transformer.
The primary current values must be within the range of the lower chart of page 28 ±10%.

12.1 Measuring of the resonance frequency

The resonance frequency of

– the parallel primary coils (anode and cathode) at a 50kW generator driven by 1 converter only

or

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– the individual primary coils (anode or cathode) at a 65/80kW driven by 1 converter each

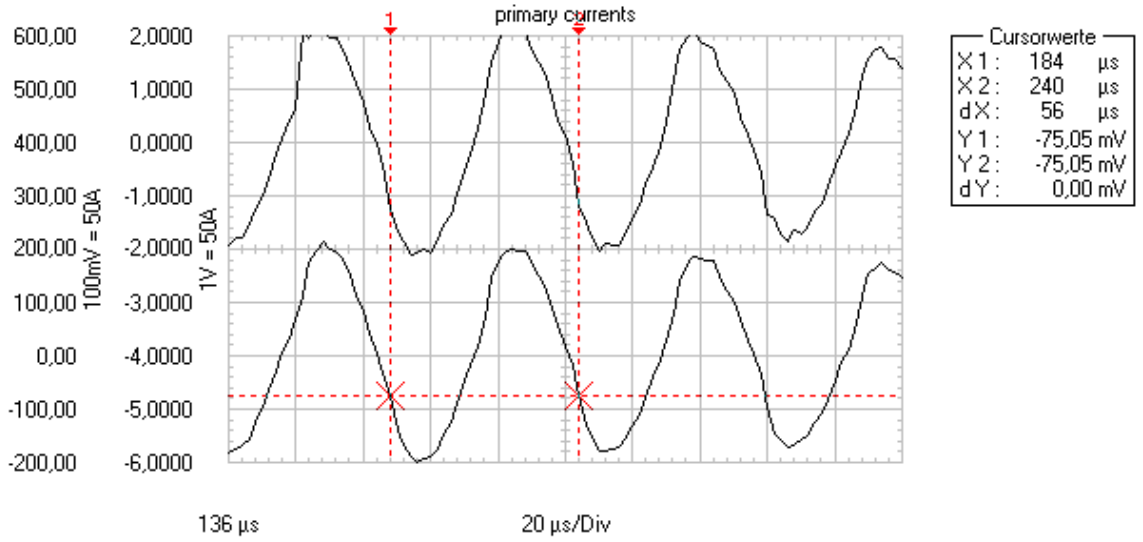
must always be the same.

With a tolerance of 5% for the primary coil inductance and for the resonance capacitors in the converters the resonance frequency must be within a range of 17.160kHz (1/f = 58.3µs) and 18.970kHz (1/f = 52.7µs).

Optimus **65/80** with **2** converters:
Both currents must be in phase (if not check probes at current transformer pins 1 + 2).

- Compare with chart.

It does not matter whether the tube is adapted or not.



(Fig. 21)

Optimus **50**:
If the resonance frequency is not within the specified range the suspected part might be

– the HV transformer
– the resonance capacitor(s) of the converter.

Optimus **65/80**:
Both resonance frequencies must be within the specified range. If not the suspected part might be

– the HV transformer
– the resonance capacitor(s) of the individual converter.

12.2 Measurement of kV behavior with an adapted tube

- Switch OFF the generator and wait until the converter DC is discharged.
- Place one oscilloscope probe at

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EZ130 X4 AV_AN actual value high voltage **anode**
and
ground EZ130 X6.

Settings see chart.

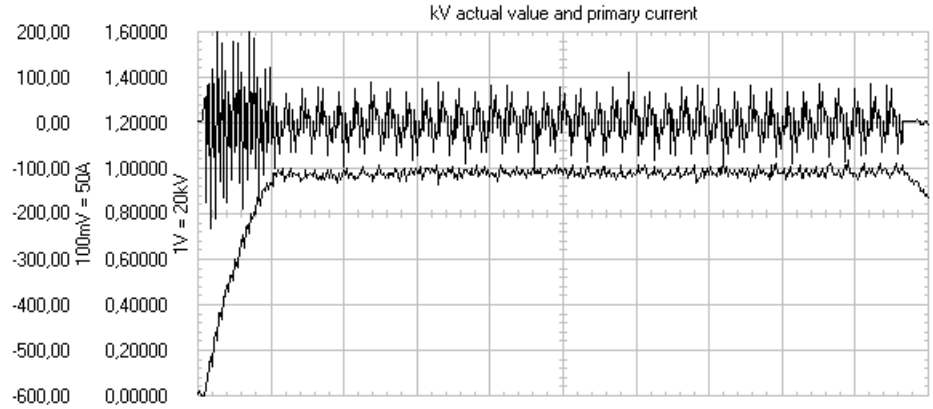
The second probe remains at the primary current anode side (frontal converter 65/80kW or the frontal converter of Optimus 50).

- Switch an exposure and compare with chart.
- Place one oscilloscope probe at

EZ130 X5 AV_CA actual value high voltage cathode (also positive)
and
ground EZ130 X6.

- Place the second probe at the primary current cathode side (rear converter 65/80kW).
- Switch an exposure **40kV**, **50mA**, **10ms** and compare with chart.

Tube adapted:



(Fig. 22)

If kV values are not symmetrical replace HV transformer. Asymmetry error messages like 02HW (warning in the background) or 02HX (error) might also come up (measured values see detail screens error log).

Tube arcing messages like 02WG (warning in the background) or 02WH (error) might appear. These should be visible at the oscilloscope trace as break-in of kV within a time of < 10µs.

It might be a problem of the tube, either because of its age or because it has not properly been conditioned.

In case of errors 02HG (warning in the background) and 02HH (error) realign the duty cycle factor according to alignment of “Function Unit kV”, see appendix.

If a filament is not adapted, adapt it before realigning the duty cycle; otherwise the adjustment is not possible.

12.3 Measuring of kV behavior with a non-adapted tube (Optimus 65/80)

The primary current behavior is different from an adapted condition as the exposure starts with 2A filament current that is brought up to filament current limit of the selected focus once high voltage is at its nominal value. Measurements have been made at kV actual value AV_HT EZ130 X3. To check the kV symmetry, use the settings of chapter 12.2.

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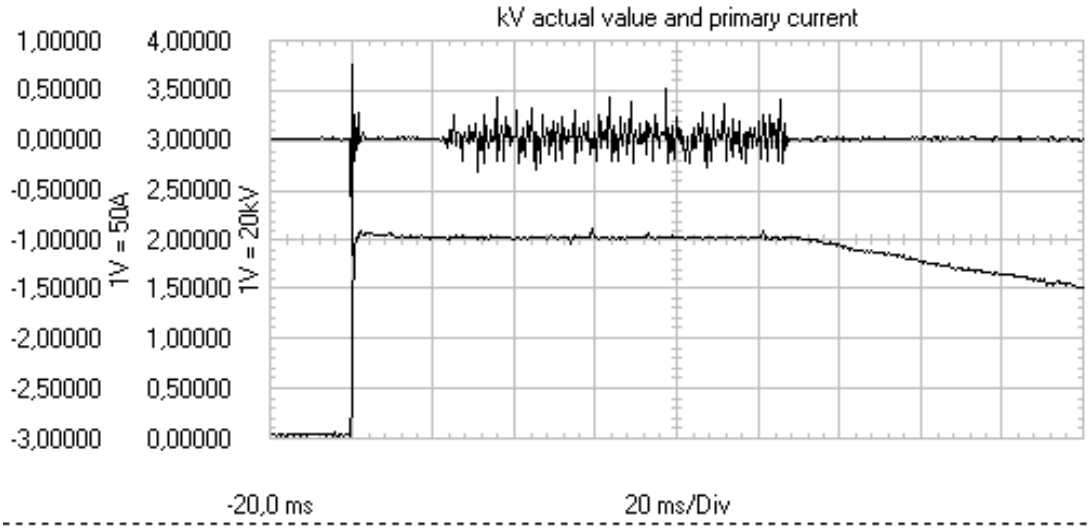
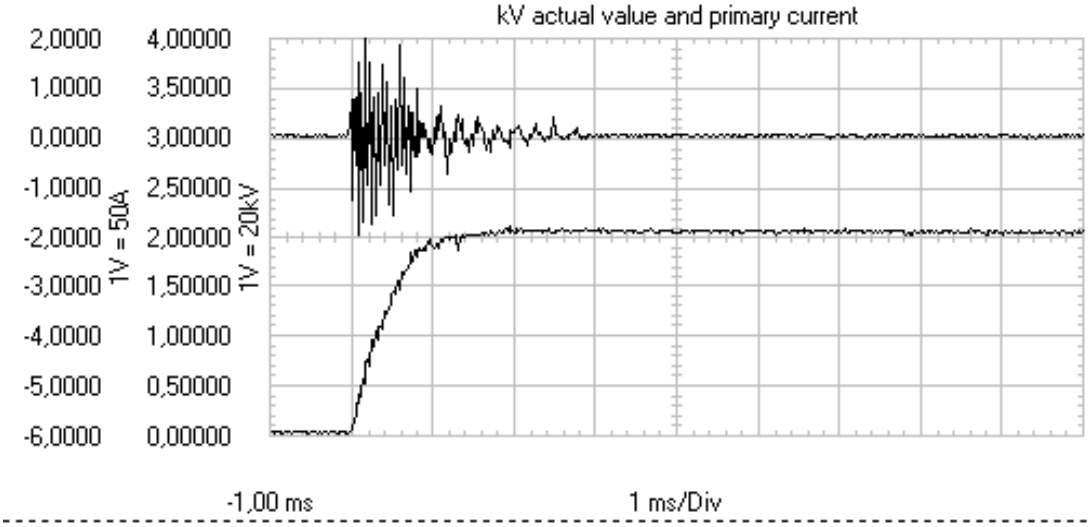


exposure 40kV 0.5mAs primary currents of a non-adapted large focus
('conditioning' mode when the desk displays "Test")
ch1 (upper signal) = EQ (frontal converter) at primary line C13:1
ch2 (lower signal) = kV actual value EZ130 X3
ch1 left scale, ch2 right scale LF3NONAD.PCX

(Fig. 23)



kV start of an
exposure 40kV 0.5mAs primary currents of a non-adapted large focus
('conditioning' mode when the desk displays "Test")
ch1 (upper signal) = EQ (frontal converter) at primary line C13:1
ch2 (lower signal) = kV actual value EZ130 X3
ch1 left scale, ch2 right scale LF2NONAD.PCX

(Fig. 24)

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13 RECONDITIONING OF THE TUBE(S)

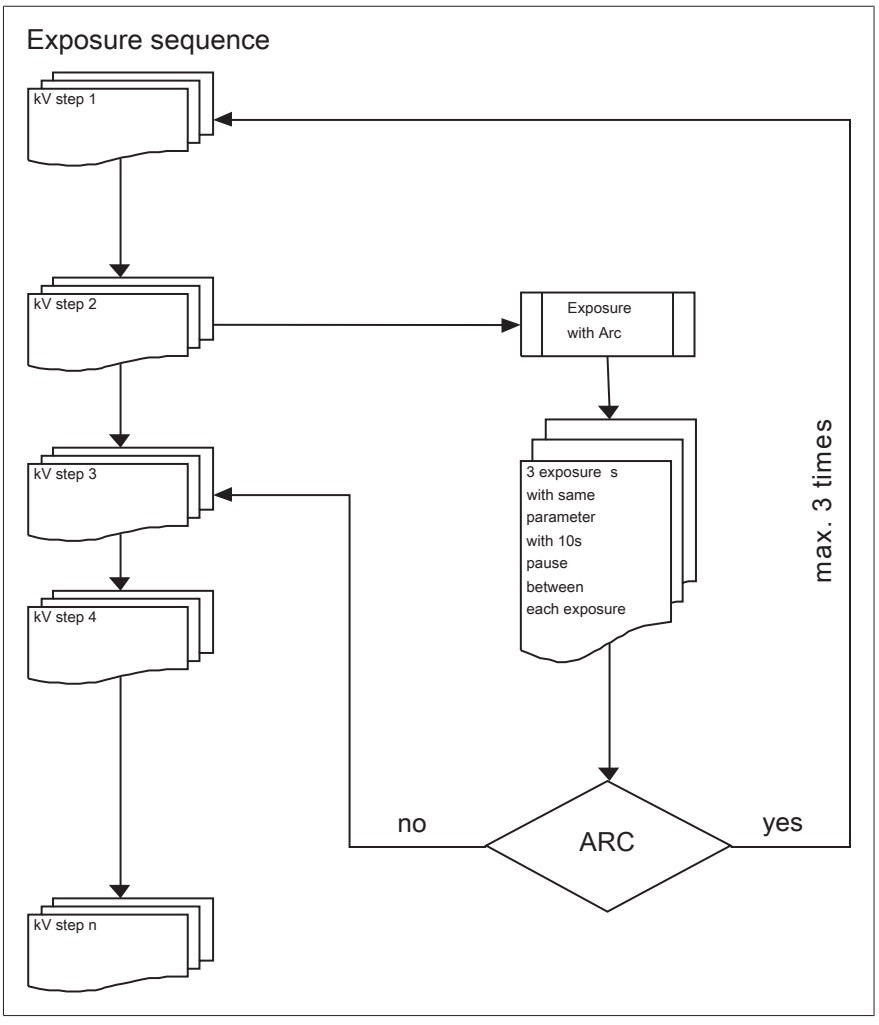
- Place one oscilloscope probe at
  EZ130 X3 AV_HT actual value high voltage (total kV, 20kV/V) and ground EZ130 X6.

Use large focus only!

- Run the reconditioning procedure (see next page) for the applicable kV range only.
  If, for instance, 125kV is the max. kV value during normal application, perform reconditioning just up to the next kV step = 130kV.

If the tube arcs at a certain kV value proceed as follows:

- Switch another three exposures with the same parameters and 10s pause between subsequent exposures.
- If the last exposure of a sequence does not arc, proceed with next kV step.
- If the last exposure still arcs, go one kV step back and start again with the normal procedure.
  If this routine has been performed three times without improvement:**==> replace the tube!**



(Fig. 25)

NOTE

If a tube arcs at a kV value that is not required for application, the max. kV (e.g.125kV) value can be reduced with
AGenT >> Program >> Tubes / Tube Limits >> max. Tube Voltage Limit [kV]: [125]

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Tube adapted				Tube not adapted	
Switch the number of exposures given for every data set of the table.					
kV	mA	ms	exposures	kV	mAs
80	10	50	< 1 >	80	0.5
80	10	500	< 1 >	80	5
80	200	250	< 1 >	80	50
10 seconds pause				10 seconds pause	
80	max mA	100	< 1 >	80	100
1 minute pause				1 minute pause	
90	10	50	< 1 >	90	0.5
90	10	500	< 1 >	90	5
90	200	250	< 1 >	90	50
10 seconds pause				10 seconds pause	
90	max mA	100	< 1 >	90	100
1 minute pause				1 minute pause	
100	10	50	< 1 >	100	0.5
100	10	500	< 1 >	100	5
100	200	250	< 1 >	100	50
10 seconds pause				10 seconds pause	
100	max mA	100	< 1 >	100	100
1 minute pause				1 minute pause	
110	10	50	< 1 >	110	0.5
110	10	500	< 1 >	110	5
110	200	250	< 1 >	110	50
10 seconds pause				10 seconds pause	
110	max mA	100	< 1 >	110	100
1 minute pause				1 minute pause	
120	10	50	< 1 >	120	0.5
120	10	500	< 1 >	120	5
120	200	250	< 1 >	120	50
10 seconds pause				10 seconds pause	
120	max mA	100	< 1 >	120	100
1 minute pause				1 minute pause	
130	10	50	< 1 >	130	0.5
130	10	500	< 1 >	130	5
130	200	250	< 1 >	130	50
10 seconds pause				10 seconds pause	
130	max mA	100	< 1 >	130	100
1 minute pause				1 minute pause	
140	10	50	< 1 >	140	0.5
140	10	500	< 1 >	140	5
140	200	250	< 1 >	140	50
10 seconds pause				10 seconds pause	
140	max mA	100	< 1 >	140	100
1 minute pause				1 minute pause	
145	10	50	< 1 >	145	0.5
145	10	500	< 1 >	145	5
145	200	250	< 1 >	145	50

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Tube adapted				Tube not adapted	
Switch the number of exposures given for every data set of the table.					
kV	mA	ms	exposures	kV	mAs
10 seconds pause				10 seconds pause	
145	max mA	100	< 1 >	145	100
1 minute pause				1 minute pause	
148	10	50	< 1 >	148	0.5
148	10	500	< 1 >	148	5
148	200	250	< 1 >	148	50
10 seconds pause				10 seconds pause	
148	max mA	100	< 1 >	148	100
1 minute pause				1 minute pause	
150	10	50	< 1 >	150	0.5
150	10	500	< 1 >	150	5
150	200	250	< 1 >	150	50
10 seconds pause				10 seconds pause	
150	max mA	100	< 1 >	150	100

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14 FINAL SYSTEM TEST

- If the generator works error-free at this stage switch it OFF and cut it from mains.

WARNING Wait at least 1 minute until the converter DC is discharged.

- Remove current transformer(s) from the primary lines and reestablish the primary lines at the resonance capacitors.
- Close the converter covers.
- Put mains and the generator back ON.
- Run a final system test with exposures and fluoroscopy, where present.

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15 APPENDIX

15.1 Alignment of function unit kV

15.1.1 General information

The actual value of the set kV must be attained at least after 2ms. At kV rise phase there must be neither kV break-in nor a kV overshoot.

The factor duty cycle is based on an adapted tube and determines at local mains voltage and mains resistance conditions:

– the kV rise phase

and

– the kV behavior during the exposure in falling load technique

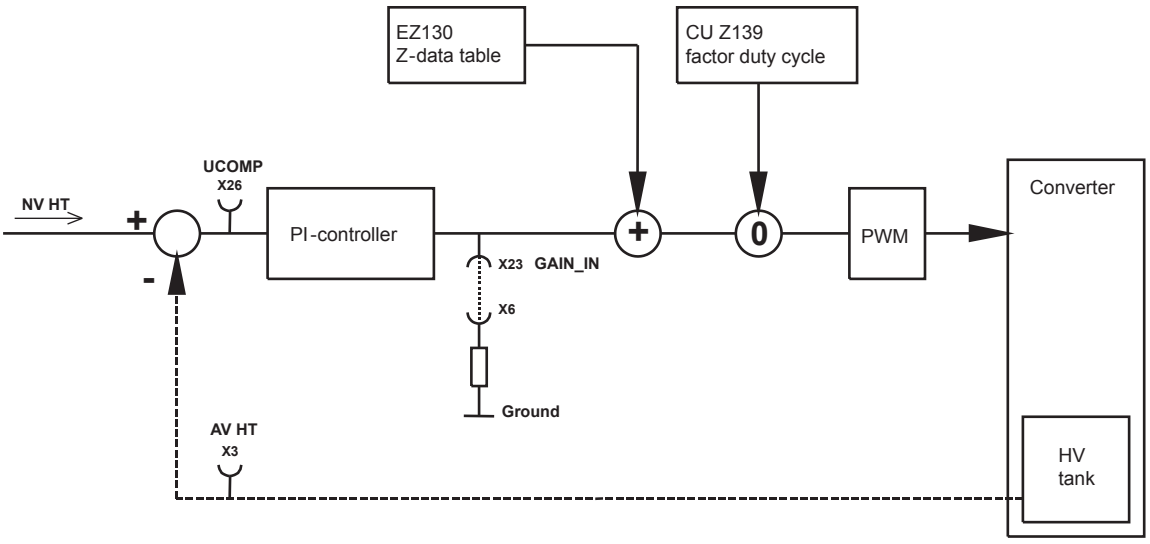
as it takes into account the tolerances of the following FRUs (Field Replaceable Units):

1.	PCB EZ 130		**
	kV_control_3 = 50kW	1 converter	4512 108 0908x / 4512 178 0026x
	kV_control_4 = 65/80kW	2 converters	4512 108 0910x / 4512 178 0028x
2.	A complete power converter unit Q		**
	kV_power PCB(s) Q100	(part of the power converter unit)	
	IGBT transistors	(part of the power converter unit)	
3.	Resonance capacitors	(part of the power converter unit)	**
4.	High-voltage transformer		**

An exchange of one of the ** marked parts requires a realignment of the factor duty cycle.

The factor duty cycle is stored in the memory of PCB CU EZ139. If the CU has to be replaced the CU complete backup can be reloaded (with the actual factor) to the NVRAM memory or the factor duty cycle must be re-aligned.

Refer to figure 26:



(Fig. 26)

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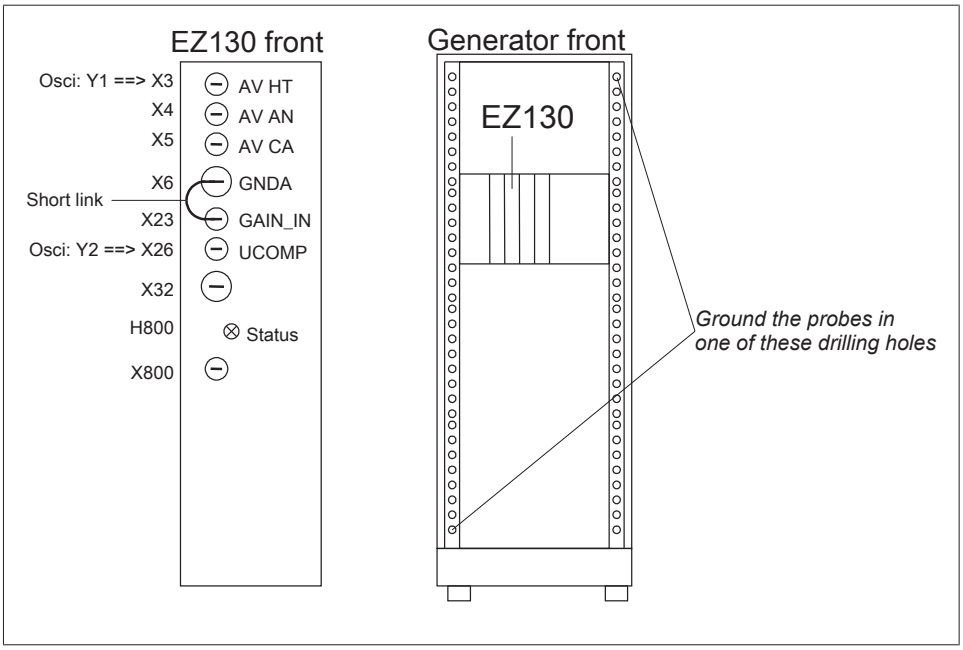
During alignment this factor duty cycle must be entered via AGenT. The influence of this factor as a correction value for the Z-data table is monitored as the U_{COMP} signal, since the PI-controller is deactivated by the grounded *GAIN_IN* signal.

15.1.1.1 Connecting and setting the scope

For connections see figure below:



(Fig. 27)

Channel 1	=	EZ130 X3 ---> AV HT ---> 20kV/V ---> 1V/div --> Zero-line at bottom of screen
Probe GND	=	one of the drilling holes at the front cabinet chassis
Channel 2	=	EZ130 X26 ---> UCOMP ---> 1V/div ---> Zero-line 2 div from bottom of screen
Probe GND	=	one of the drilling holes at the front cabinet chassis
Trigger	=	external (preferred) ---> CTRL_X_C/ ---> backpanel EZX74 / negative slope
or	=	internal channel 1 ---> AV HT ---> EZ130 X3 / positive slope at +3V
Probe GND	=	one of the drilling holes at the front cabinet chassis
Time base	=	5 or 10ms/div ---> trigger delay -1div

NOTE

A digital scope should not have any other ground connection than the ground of the three probes at the drilling holes at the front generator chassis.
A mains-driven scope must be isolated from earth potential, otherwise it might display artefacts.

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15.1.1.2 Deactivating the kV controller

- Connect EZ130 X23 GAIN_IN and X6 GNDA with a short link (use a short wire).

CAUTION

This alignment requires exposures with high kV.
Be sure the tube has been warmed up before.

15.1.1.3 Setting of exposure data

a) Set 141kV in case

– of 65/80kW generators
– the tube limit (of at least one tube) is 150kV, perform this adjustment at the tube which has the highest kV limit programmed.

b) Set 125kV in case

– of 50kW generators
and
– of 65/80kW generators if the programmed application limit of the tube limit is 125kV.

NOTE

Any tube arcing during this adjustment requires the execution of the tube conditioning next as described in Appendix (15.2.TUBE CONDITIONING).
Disconnect the short link between X23 and X6.
Start over this adjustment from chapter 15.1.1.2 onwards if the tube conditioning was successful.

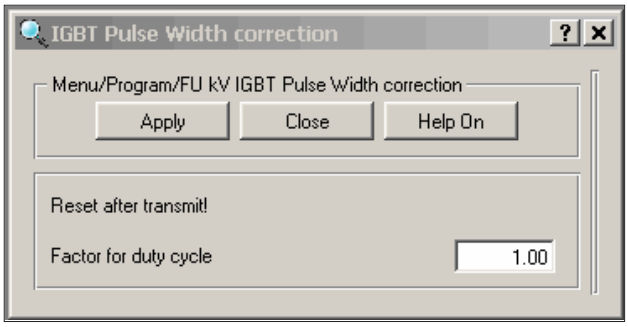
- Set kV and mA values according to the programmed tube limits:

a)	**141kV:**	**200mA**	**at kV_4**	**(65/80kW)**
b)	**125kV:**	**100mA**	**at kV_3**	**(50kW)**
		200mA	**at kV_4**	**(65/80kW)**

- Set the exposure time: 40ms

15.1.1.4 Adjustment of the factor for duty cycle

- Adjust the factor duty cycle via service software AGenT by measuring UCOMP with the scope.
- Connect the service PC and start AGenT:
  Select Menu: Program / FU kV IGBT Pulse Width Correction
- Set the starting value Factor Duty Cycle to 1.00:



(Fig. 28)

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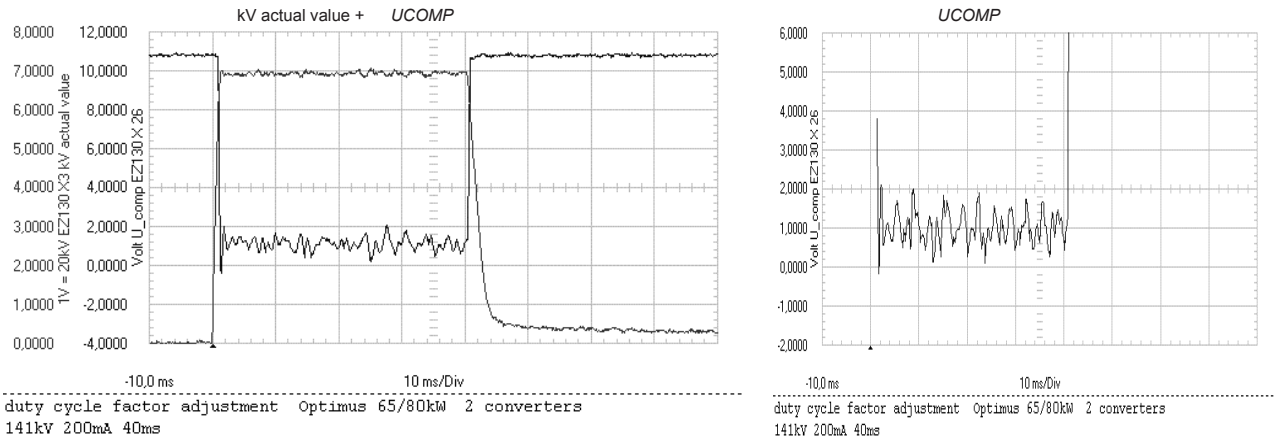
- If the UCOMP value does not match the requirements type in another factor duty cycle value, transmit the factor by clicking on “Apply” with the left mouse button and push the active RGDV button to get the new value validated.
- Switch an exposure.
  The values are measured in the stationary condition. The transient behavior at the beginning of the exposure is not taken into account.

Result: In standby the U_{COMP} value is at about +11V, during exposure the mean value UCOMP must be as given in table 1 or 2, refer to figure 29:



Oscillogram of a perfect alignment for 141kV

UCOMP for 141kV

(Fig. 29)

a) 141kV setting (65/80kW only)

- Read the mean value of U_{COMP} for 141kV (see scope figure 29 or 30), correct the factor duty cycle till U_{COMP} meets the required reference of +1V.

kV setpoint	mA setpoint	PCB type	U_{COMP}	Tolerance	kV peak of *AV HT*	Factor duty cycle:	Date
141kV	200mA	PCB kV_control 4:	+1V	±0.5V	138kV		

Table 1: Factor duty cycle, settings 141kV (150kV limit)

Example how to correct the factor duty cycle:

PCB kV_control 4:

- If the mean value of U_{COMP} is: > +1.5V increase the factor duty cycle in steps of 0.01
  < +0.5V decrease the factor duty cycle in steps of 0.01
- Check also the kV peak value AV HT (not the overshoot), it must be 138kV for 141kV setpoint (see scope figure 30).
- Remove short link EZ130 X23 GAIN_IN.
- Record the results in table 1.

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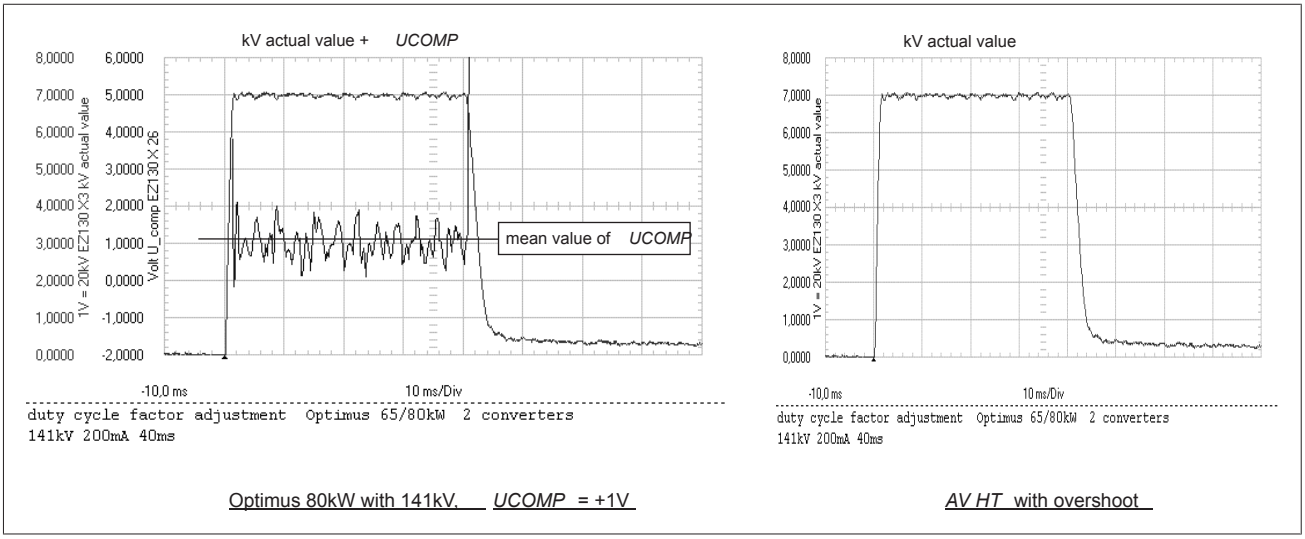
kV actual value + UCOMP
mean value of UCOMP
duty cycle factor adjustment Optimus 65/80kW 2 converters
141kV 200mA 40ms
kV actual value
duty cycle factor adjustment Optimus 65/80kW 2 converters
141kV 200mA 40ms

Optimus 80kW with 141kV, *UCOMP* = +1V

AV HT with overshoot

(Fig. 30)

b) 125kV setting (50/65/80kW)

- Read the mean value of U_{COMP} for 125kV (in principle figure 29 or 30).
- Correct the factor duty cycle till U_{COMP} meets the required reference of 0V.

kV setpoint	mA setpoint	PCB type	U_{COMP}	Tolerance	kV peak of *AV HT*	Factor duty cycle:	Date:
125kV	100mA	PCB kV_control 3:	+0V	+1V / -0,5V	125kV		
125kV	200mA	PCB kV_control 4:	+0V	±0.5V	125kV		

Table 2: Factor duty cycle, 125kV limit

Example how to correct the factor duty cycle:

PCB kV_control 3:

- If the mean value of UCOMP is: > +1V increase the factor duty cycle in steps of 0.01
  < -0.5V decrease the factor duty cycle in steps of 0.01

PCB kV_control 4:

- If the mean value of UCOMP is: > +0.5V increase the factor duty cycle in steps of 0.01
  < -0.5V decrease the factor duty cycle in steps of 0.01

- Check also the kV peak value AV HT (not the overshoot), it must be 125kV for 125kV setpoint.
- Remove short link EZ130 X23 GAIN_IN.
- Record the results in table 2.

15.2 TUBE CONDITIONING

15.2.1 General Information

WARNING Radiation is released during the conditioning procedure!

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The generator must be in the READY state, i.e. the green ring at the desk must be illuminated.

15.2.2 Preconditions / Program settings

- Switch OFF the generator.

Preparation of generators which are connected via a CAN interface:

– BuckyDiagnost TH and TH2
– DigitalDiagnost
– Thoravision
– EasyDiagnost with bucky unit.

- Disconnect the following plugs.

System	Connector		
	EZX23 or EZX23-1 signal bus	EZX42 or EZX42-1 system CAN	EZX43 or EZX43-1 system CAN
BuckyDiagnost TH / TH2	X		X
DigitalDiagnost	X	X	X
Thoravision	X	X	X
EasyDiagnost with bucky unit	X	X	X

- Switch ON the generator.

NOTE

The programming procedure must not be started before relay ENK1 has been energized at least 2 minutes after the generator has been switched on.

- Perform the following program settings temporarily for each tube connected to one of the assigned

  RGDVs = Free cassette
  Select menu AGenT:
  Program / RGDV set A + B / RGDV 1 ... 8 / Data Set A

Program setting	Temporarily	Original Tube
Enable handswitch	YES	
Syncmaster present	NO	
Exposure switch type	Double Step	
Exposure series / Tomo	YES	
Mounted radiographic	NONE	

- Reset the generator.
- Select appropriately programmed RGDV = “Free cassette” for the tube to be conditioned.

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15.2.3 Procedure

- Select **large** focus only.

NOTE

The generator must be in the READY state.

- Run reconditioning procedure for an adapted tube. Refer to the following table, left column “Tube adapted”.

or

- Run conditioning procedure for a new or non–adapted tube. Refer to the following table right column “Tube not adapted”.
- It is recommended that the high voltage be monitored during conditioning.

  Connect the scope:

Channel1:	kV AV HT at EZ130 X3 (1V/div), scale: 20kV/V
Trigger external:	CTRL_X_C/ at backpanel EZ X74, negative slope
Time base:	2ms/div

- In case of problems like tube arcing see the following flowchart EXPOSURE SEQUENCE as an example. The flowchart applies to the applicable kV range only, e. g.:
  109kV is the max. kV value for normal application, set the next higher kV step = 117kV.

NOTE

Refer to flowchart EXPOSURE SEQUENCE.
If the tube arcs at a certain kV value, switch another three exposures with same parameters and 10s pause between subsequent exposures. In case of success (no arcing anymore) continue with next kV step of the following table.
If the last exposure still arcs go one kV step back and follow the normal procedure. If this routine has been performed three times without improvement: **==> Replace the tube!**

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Exposure parameters for conditioning					
Tube adapted			# Exposures	Tube not adapted	
kV	mA	ms		kV	mAs
80	10	50	< 1 >	80	0.5
80	10	500	< 1 >	80	5
80	200	250	< 1 >	80	50
10 seconds pause				10 seconds pause	
80	max. mA	100	< 1 >	80	100
1 minute pause				1 minute pause	
90	10	50	< 1 >	90	0.5
90	10	500	< 1 >	90	5
90	200	250	< 1 >	90	50
10 seconds pause				10 seconds pause	
90	max. mA	100	< 1 >	90	100
1 minute pause				1 minute pause	
100	10	50	< 1 >	100	0.5
100	10	500	< 1 >	100	5
100	200	250	< 1 >	100	50
10 seconds pause				10 seconds pause	
100	max. mA	100	< 1 >	100	100
1 minute pause				1 minute pause	
110	10	50	< 1 >	110	0.5
110	10	500	< 1 >	110	5
110	200	250	< 1 >	110	50
10 seconds pause				10 seconds pause	
110	max. mA	100	< 1 >	110	100
1 minute pause				1 minute pause	
120	10	50	< 1 >	120	0.5
120	10	500	< 1 >	120	5
120	200	250	< 1 >	120	50
10 seconds pause				10 seconds pause	
120	max. mA	100	< 1 >	120	100
1 minute pause				1 minute pause	
130	10	50	< 1 >	130	0.5
130	10	500	< 1 >	130	5
130	200	250	< 1 >	130	50
10 seconds pause				10 seconds pause	
130	max. mA	100	< 1 >	130	100
1 minute pause				1 minute pause	

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Exposure parameters for conditioning					
Tube adapted			# Exposures	Tube not adapted	
kV	mA	ms		kV	mAs
140	10	50	< 1 >	140	0.5
140	10	500	< 1 >	140	5
140	200	250	< 1 >	140	50
10 seconds pause				10 seconds pause	
140	max. mA	100	< 1 >	140	100
1 minute pause				1 minute pause	
145	10	50	< 1 >	145	0.5
145	10	500	< 1 >	145	5
145	200	250	< 1 >	145	50
10 seconds pause				10 seconds pause	
145	max. mA	100	< 1 >	145	100
1 minute pause				1 minute pause	
148	10	50	< 1 >	148	0.5
148	10	500	< 1 >	148	5
148	200	250	< 1 >	148	50
10 seconds pause				10 seconds pause	
148	max. mA	100	< 1 >	148	100
1 minute pause				1 minute pause	
150	10	50	< 1 >	150	0.5
150	10	500	< 1 >	150	5
150	200	250	< 1 >	150	50
10 seconds pause				10 seconds pause	
150	max. mA	100	< 1 >	150	100
1 minute pause				1 minute pause	

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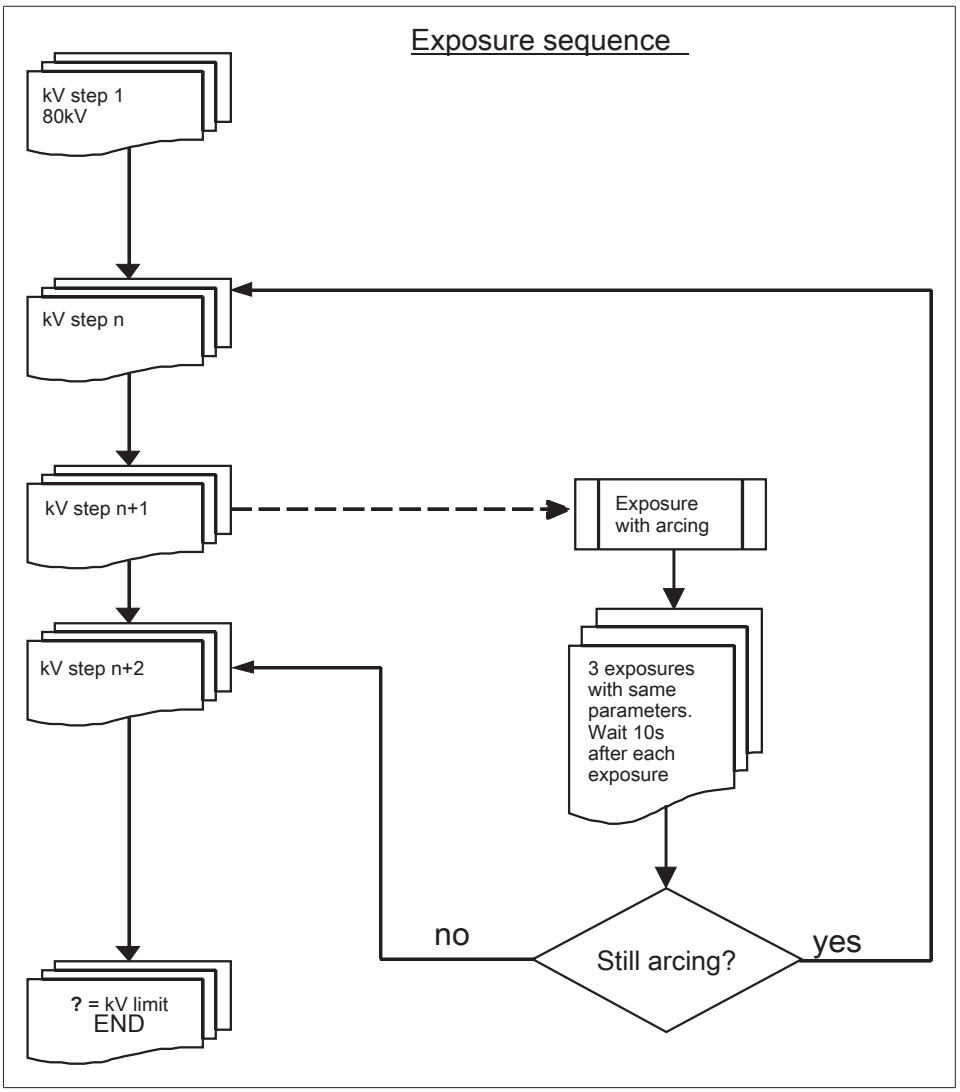

(Fig. 31)

NOTE

If a tube arcs at any kV value which is not required for application, program the max. application kV value with AGenT:
Program / Tubes / Tube Limits / Max. Tube Voltage Limit [kV] / [117]

As the max. kV value has decreased now, the field ADAPTED TO [kV] displays the max. value after adaptation as well.

- Set the RGDV programming to the original status if no adaptation procedure has to be executed.
- Reset the generator.

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15.3 List of checked parts of generator S/N

Please add this list to returned parts.

ENK2		phase 1	1 - 2	❒ open	❒ welded			
		phase 2	3 - 4	❒ open	❒ welded			
		phase 3	5 - 6	❒ open	❒ welded			
EN	**: R1**			❒ open				
	: R2			❒ open				
	: R3			❒ open				
ENF1		L1 – T1		❒ open	❒ welded			
		L2 – T2		❒ open	❒ welded			
		L3 – T3		❒ open	❒ welded			
ENF2		L1 – T1		❒ open	❒ welded			
		L2 – T2		❒ open	❒ welded			
		L3 – T3		❒ open	❒ welded			
ENK1	phase 1		2 – 1	❒ open	❒ welded			
	phase 2		4 – 3	❒ open	❒ welded			
	phase 3		6 – 5	❒ open	❒ welded			
Rectifier		**EQV5**	EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
IGBT 1			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
IGBT 2			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
IGBT 3			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
IGBT 4			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Diode V501			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Diode V502			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Diode V503			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Diode V504			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Resistors R506/507/508			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Resistors R509/510/511			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Cable harness			EQ	❒ 2 = OK	❒ 1 = defective	E2Q	❒ 2 = OK	❒ 1 = defective
>> Converter	**EQ**	❒ OK		❒ defective	unit barcode# frontal: _____			
	E2Q	❒ OK		❒ defective	unit barcode# rear (65/80kW only):_____			
Res. capacitor C3			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Res. capacitor C13			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
H.V. cable				❒ OK	❒ defective			
X-Ray tube 1	❒ OK			❒ defective	tube type:_____		tube S/N:_____	
X-Ray tube 2	❒ OK			❒ defective	tube type:_____		tube S/N:_____	
H.V. transformer	❒ OK			❒ defective	tank S/N:_____			

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15.4 List of checked parts of generator S/N

Please add this list to returned parts.

ENK2		phase 1	1 - 2	❒ open	❒ welded			
		phase 2	3 - 4	❒ open	❒ welded			
		phase 3	5 - 6	❒ open	❒ welded			
EN	**: R1**			❒ open				
	: R2			❒ open				
	: R3			❒ open				
ENF1		L1 – T1		❒ open	❒ welded			
		L2 – T2		❒ open	❒ welded			
		L3 – T3		❒ open	❒ welded			
ENF2		L1 – T1		❒ open	❒ welded			
		L2 – T2		❒ open	❒ welded			
		L3 – T3		❒ open	❒ welded			
ENK1	phase 1		2 – 1	❒ open	❒ welded			
	phase 2		4 – 3	❒ open	❒ welded			
	phase 3		6 – 5	❒ open	❒ welded			
Rectifier		**EQV5**	EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
IGBT 1			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
IGBT 2			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
IGBT 3			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
IGBT 4			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Diode V501			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Diode V502			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Diode V503			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Diode V504			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Resistors R506/507/508			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Resistors R509/510/511			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Cable harness			EQ	❒ 2 = OK	❒ 1 = defective	E2Q	❒ 2 = OK	❒ 1 = defective
>> Converter	**EQ**	❒ OK		❒ defective	unit barcode# frontal: _____			
	E2Q	❒ OK		❒ defective	unit barcode# rear (65/80kW only):_____			
Res. capacitor C3			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Res. capacitor C13			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
H.V. cable				❒ OK	❒ defective			
X-Ray tube 1	❒ OK			❒ defective	tube type:_____		tube S/N:_____	
X-Ray tube 2	❒ OK			❒ defective	tube type:_____		tube S/N:_____	
H.V. transformer	❒ OK			❒ defective	tank S/N:_____			

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15.5 List of checked parts of generator S/N

Please add this list to returned parts.

ENK2		phase 1	1 - 2	❒ open	❒ welded			
		phase 2	3 - 4	❒ open	❒ welded			
		phase 3	5 - 6	❒ open	❒ welded			
EN	**: R1**			❒ open				
	: R2			❒ open				
	: R3			❒ open				
ENF1		L1 – T1		❒ open	❒ welded			
		L2 – T2		❒ open	❒ welded			
		L3 – T3		❒ open	❒ welded			
ENF2		L1 – T1		❒ open	❒ welded			
		L2 – T2		❒ open	❒ welded			
		L3 – T3		❒ open	❒ welded			
ENK1	phase 1		2 – 1	❒ open	❒ welded			
	phase 2		4 – 3	❒ open	❒ welded			
	phase 3		6 – 5	❒ open	❒ welded			
Rectifier		**EQV5**	EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
IGBT 1			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
IGBT 2			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
IGBT 3			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
IGBT 4			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Diode V501			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Diode V502			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Diode V503			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Diode V504			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Resistors R506/507/508			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Resistors R509/510/511			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Cable harness			EQ	❒ 2 = OK	❒ 1 = defective	E2Q	❒ 2 = OK	❒ 1 = defective
>> Converter	**EQ**	❒ OK		❒ defective	unit barcode# frontal: _____			
	E2Q	❒ OK		❒ defective	unit barcode# rear (65/80kW only):_____			
Res. capacitor C3			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Res. capacitor C13			EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
H.V. cable				❒ OK	❒ defective			
X-Ray tube 1	❒ OK			❒ defective	tube type:_____		tube S/N:_____	
X-Ray tube 2	❒ OK			❒ defective	tube type:_____		tube S/N:_____	
H.V. transformer	❒ OK			❒ defective	tank S/N:_____			

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